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Atlantic Surf Clam Fishery

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On the cover: A modern stern-dredge clam vessel.

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The Atlantic Coast Surf Clam Fishery, 1965-1974

JOHN W. ROPES

Introduction

An intense, active fishery for the Atlantic surf clam, *Spisula solidissima,* developed from one that historically employed unsophisticated harvesting and marketing methods and had a low annual production of less than 2 million pounds of meats (Yancey and Welch, 1968). Only 3.2 percent of the clam meats landed by weight in the United States during the half-decade 1939-44 were from this resource, but by 1970-74 it amounted to 71.8 percent. Landings from this fishery during the three-decade period 1945-74 increased the post-World War II per capita consumption of clams in the United States twofold from 0.268 pounds in 1947 to 0.589 pounds in 1974 (NMFS, 1975). Much of this consumption was in the New England region (Miller and Nash, 1971).

The fishery is centered in the ocean off the Middle Atlantic coastal states, since surf clams are widely distributed in beds on the continental shelf of the Middle Atlantic Bight (Merrill and Ropes, 1969; Ropes, 1979). Most of the vessels in the fishery are located from the State of New York through Virginia. The modern-day industry made several innovative technological advances in equipment for catching and processing the meats which significantly increased production.

The industry steadily grew during the 1950's with an increase in demand for its products, but by the early 1960's industry representatives suspected that the known resource supply was being depleted and requested research assistance (House of Representatives, 1963). As part of a Federal research program begun in 1963 (Merrill and Webster, 1964), vessel captains in the surf clam fleet were interviewed to gather data on fishing location, effort, and catch. Ten annual reports on the fishery during 1965-74 are available

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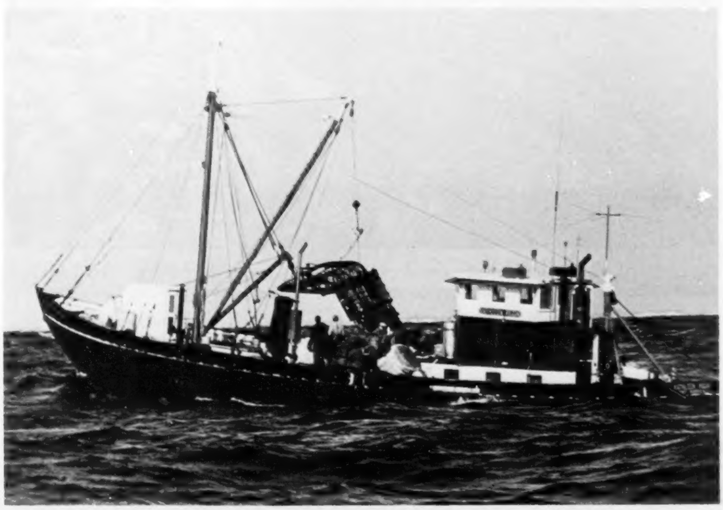
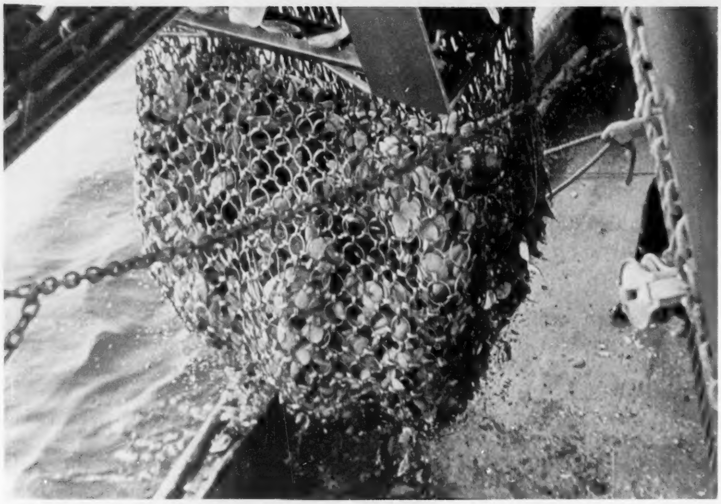
ABSTRACT—This report includes historical highlights of the Atlantic coast surf clam, Spisula solidissima, *fishery, and summarizes fishing operations during 1965-1974, a period of increased exploitation and growth in the Middle Atlantic Bight. Landings increased almost every year during the 10-year period, often setting new catch records, and accounted for more than half (about 60 percent) of the domestic clam meat landings (by weight) in the United States; landings averaged 44.7 million pounds annually during the first 5 years and increased to 72.3 million pounds in the last 5 years. This latter value included the peak 96.1 million-pound yield attained in 1974.*

During the 10-year period, the most significant events were increased effort, in the form of additional larger vessels with greater fishing capabilities; a drastic decline in surf clam stocks off Point Pleasant, N.J., one of the traditional and principal ports for landings; and transfer of vessels to more southern ports and expansion of fishing operations on newly discovered beds off the Delmarva Peninsula and Virginia. These latter stocks sustained the very high annual yield in the 1970-1974 period. Major pre- and post-study period events through 1977 are discussed.



Dredge hanging in the rigging to dump the catch of clams.



Ring-bag full of clams and shells just before dumping.

Pile of clams and shells on deck; crewman tying the dredge ring-bag preparatory to setting and the next tow.

Groutage and Barker, 1967a,b; Yancey, 1968, 1970; Barker and Ropes, 1971; Ropes and Barker, 1972; Ropes et al., 1972; Ropes, Barker, and Ward, 1975; Ropes, Merrill, and Ward, 1975; and Ropes and Ward, 1977); and a summary report for the period 1965-69 (Ropes, 1972). The following summarizes the data collected during the 1965-74 study period and major pre- and post-study period events in the fishery through 1977. Similar interview data were not collected in the New England region because the fishery there produced relatively insignificant landings, although records of landings are included for comparison with those of the Middle Atlantic region.

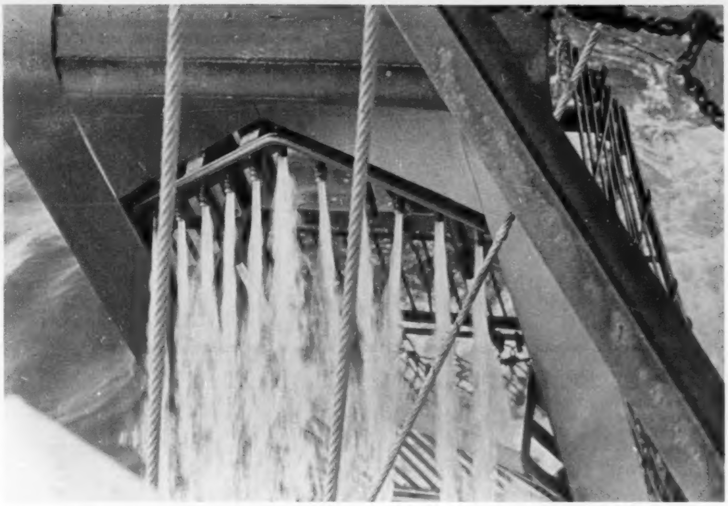
The Resource and Fishery

The modern-day surf clam fishery operated for almost two decades (1945-65) with limited knowledge about the location and extent of the resource on the northwestern Atlantic continental shelf. Federal programs of exploration, gear improvement, and biological research were developed expressly to provide such knowledge (Merrill and Webster, 1964). Surveys focusing on known and suspected surf clam fishing areas begun in 1963 complement observations on the general distribution of surf clams reported below (Parker, 1965, 1966; Parker and Fahlen, 1968).

The first major biological surveys of ocean clam resources were conducted in 1965. The survey area was from Cape Hatteras, N.C., to Montauk Point, N.Y., and from nearshore to depths beyond commercial exploitation. Data from these surveys and other records were used to describe the general distribution of surf clams by Merrill and Ropes (1969) and have been made available by Ropes and Merrill (1971). The survey results provided similar observations on ocean quahogs, *Arctica islandica,* a species considered only of potential use in fishery products at that time. Ropes and Merrill (1976) provided additional data for surveys in 1965, 1966, 1967, 1969, 1970, and 1974. Ropes (1979) reviewed the biology of ocean clams and summarized available survey data through 1977 for a comprehensive account of distribution in the Middle Atlantic Bight. Serchuk et al. (1979) reviewed historical trends in landings as they relate to stock abundance and provided a current assessment of the

Middle Atlantic Bight surf clam resource.

The generic name *Spisula* is used for several bivalves commonly known as surf clams (Ropes et al., 1969). Three species of *Spisula* inhabit the northwestern Atlantic continental shelf (Abbott, 1974; Bousfield, 1960). A maximum shell length of 226 mm (8.9 inches) reported for *S. solidissima* by Ropes and Ward (1977) characterizes it as the largest species of *Spisula*. Its latitudinal range extends from the southern Gulf of the St. Lawrence, Canada, to Cape Hatteras, N.C. (Merrill and Ropes, 1969; Ropes, 1979). *S. polynma,* a boreal species, attains a shell length of 150 mm (5.9 inches) and inhabits deep-water locations north of Long Island; *S. raveneli,* a littoral species, rarely is larger than 75 mm (3.0 inches) and is found south of Cape Hatteras. Both the latter species are thought to be distributed beyond the areas fished for *S. solidissima* in the Middle Atlantic Bight. In this area *S. solidissima* is found from the coastal beach zone to 36 fathoms (65.5 m) depths and in about 13,000 n.mi.^{2} (44,600 km^2) of the oceanic shelf (Ropes, 1979). It occurs in sand, gravel, and mixed silty-sand substrata. Survey records suggest it is probably one of the dominant infaunal macroinvertebrates throughout much of its distributional range in the Middle Atlantic Bight (Steimle and Stone, 1973; Garlo et al., 1974). The concentrations of interest to the fishery occur from shore to depths of about 10 fathoms (18.3 m) off Long Island, N.Y., and to 20-fathom (36.6 m) depths off New Jersey. Off the Delmarva Peninsula (Delaware, Maryland, and Virginia) and the Virginia-North Carolina coasts, they are concentrated at 10-20 fathoms (18.4-36.6 m).



Bottom view of a hydraulic dredge hanging alongside a vessel with water jetting out of the nozzles and between the 10-inch-wide runners. The jets of water loosen the sand and wash clams into the dredge as it is being towed.

Clams are sorted into a bushel metal hopper that is inserted into the mouth of a bag. The hopper and bag are picked up sliding the clams into the bag, which is then stacked on deck.

Vessels and Gear

Many of the vessels in the surf clam fleet were converted from other fisheries or other uses. Some were built with the express purpose of fishing for surf clams, although the original design of many of these was for use in the shrimp fishery. Their age composition varied, and a few almost 100 years old were active throughout the 10-year interview period (Table 1). In 1965, 77 percent of the vessels had been built before 1950. By 1969, several newer

Table 1.—Surf clam fleet age composition in 1965, 1969, and 1974

Year vessel built	Percent of fleet		
	1965	1969	1974
1875-1899	6	6	4
1900-1924	21	13	16
1925-1949	50	40	31
1950-1965	23	—	—
1966-1969	—	41	42
1970-1974	—	—	7

Table 2.—Gross tons of vessels in the surf clam fishery in 1965, 1969, and 1974

Gross tons	Percent of fleet		
	1965	1969	1974
≤25	11.3	7.1	6.3
26-50	38.7	34.0	27.3
51-75	43.6	37.7	25.3
76-100	3.2	16.5	21.1
≥101	3.2	4.7	20.0

Table 3.—Number of vessels landing surf clams in five Middle Atlantic states, 1965-74.

State	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
New York	5	5	7	7	7	7	7	7	7	6
New Jersey	48	55	60	72	67	55	48	44	50	44
Delaware	—	—	—	—	4	7	8	8	3	3
Maryland	1	1	3	7	14	14	13	18	17	13
Virginia	—	—	—	—[1]	—[1]	4	16	23	21	32
Total	54	61	70	86	92	87	92	100	98	98

[1]Migrant.

vessels had entered the fishery, and the proportion built after 1949 increased from 23 to 41 percent. Steel-hulled, stern-dredge vessels specifically designed for surf clamming entered the New Jersey fleet in 1969 (Ropes, 1972). These were the forerunners of vessels built or converted in the next 5 years for more intense, long-distance fishing. By 1974, almost half (49 percent) of the vessels in the fleet had been built after 1949. Many of the new vessels added to the fleet were of the stern-dredge design and others had made the conversion.

Vessel size, as reflected in gross tons (GT), increased during the interview period (Table 2). In 1965, most vessels (82.3 percent) ranged from 26 to 75 GT and more (11.3 percent) were less than or equal to 25 GT than over 75 GT (6.4 percent). Most (71.7 percent) of the vessels were again of the 26-75 GT size range in 1969, but more (21.2 percent) were in the over-75 GT category. The greatest change occurred after 1969. In 1974, 41.1 percent of the fleet were vessels over 75 GT. Vessels of 76-100 GT and equal to or over 101 GT were almost equally represented in the fleet. Larger vessels, then, had been acquired to handle the stern-dredge and ramp systems, which permitted greater participation in a rapidly expanding fishery during the study period.

Dredge size has increased since 1945 (Parker, 1971) and continued to increase during the 10-year interview period. Although exact data are not available since dredge construction varies in specific details, some of which are dimensional and others operational, knife-width measures one dimension of the area fished and is constant for any particular dredge. An experimental hydraulic dredge with a knife width of 9 inches (22 cm) has been constructed that is fully functional in sampling clams (Snow[1]) and is about the size used in the earliest active fishery for surf clams. In 1965, the knife widths were mostly 40-48 inches (102-122 cm), and by 1969, larger dredges with 60-inch wide (152 cm) knives were common in the fishery (Ropes, 1972). With the development of the stern-dredge system, dredges with 100- and 120-inch (254 and 305 cm) knives were in operation by 1974, although most were not wider than 84 inches (213 cm).

[1]Snow, H.F. 1976. Snow Food Products, P.O. Box F, Old Orchard, ME 04064. Pers. Commun.

Ports, Number of Vessels, and Landings

Several ports received landings of surf clams during the study period: Freeport, Long Island, N.Y.; Point Pleasant, Barnegat, Atlantic City, and Cape May-Wildwood, N.J.; Lewes, Del.; Ocean City, Md.; Chincoteague, Cape Charles, Kiptopeake, Oyster, and Little Creek, Va. Although small quantities of surf clams for bait were sometimes landed at some of these ports, landings at Brooklyn, N.Y., and Brielle, N.J., were exclusively of this type of product.

The number of surf clam vessels landing surf clams in the five states varied throughout the study period (Table 3). At New York ports, the numbers were relatively low and stable, ranging from 5 to 7. The number of vessels was greatest and

Heading for port with the dredge and bags of clams stowed on deck.

more variable at New Jersey ports. They increased from 48 to 72 during the early half-decade of the study period and declined thereafter to 44. This decline resulted from vessel transfers to ports in the more southerly states, particularly after the discovery of unfished beds off the Delmarva Peninsula coast during the early surveys mentioned above. Landings in Delaware were reported only for the years 1969-74; the number of vessels landing in Delaware ranged between 4 and 8. The home port of these vessels was in New Jersey, with most of their catch originating in New Jersey waters. Surf clams were landed in Maryland by a few vessels in the 1950's, but their numbers had dwindled to only one by the beginning of the study period. The two vessels added to the fleet in 1967 were the forerunners of a displacement of vessels away from New Jersey ports. By the last half-decade of the study period, from 14 to 18 vessels landed in Maryland. Landings were made at Virginia ports in 1968 and 1969, but the quantities were low, suggesting that a few vessels had explored the nearby waters and dock facilities. In 1970, four vessels operated from Virginia ports; that vessel number increased to 32 by 1974.

Vessel occurrence in an area varied from month to month and some vessels were considered migrants (Ropes, Barker, and Ward, 1975; Ropes, Merrill, and Ward, 1975; Ropes and Ward, 1977). The numbers of vessels shown in Table 3 are those consistently making landings in a particular state for a year.

Monthly surf clam landings during 1965-74 for five Middle Atlantic coastal states have been graphed and the mean monthly values for each year plotted to show trends (Fig. 1). New York landings were relatively low and stable throughout the study period. Monthly values ranged from less than 0.1 million pounds for January 1965 to 0.5 million pounds for September 1970. Mean monthly landings ranged from 0.1 to 0.4 million pounds in 1965 and 1970, respectively. The average monthly landing for the 10-year period was 0.25 million pounds, and 30.0 million pounds was harvested.

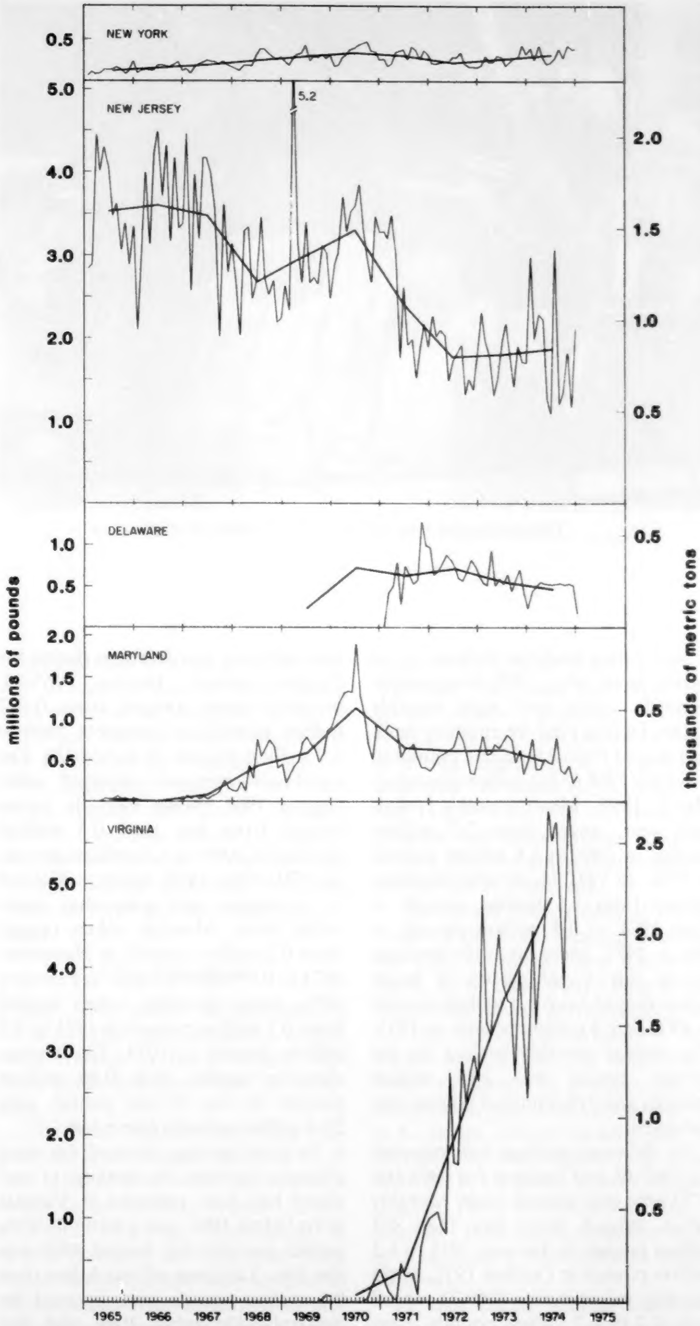


Figure 1.—Monthly landings of surf clams by weight in New York, New Jersey, Delaware, Maryland, and Virginia, and mean monthly values during 1965-74.

The dredge and bags of clams viewed from above.

New Jersey landings declined to the lowest levels after 1970 from earlier relatively stable and high monthly values. During 1965-69, monthly landings ranged from 2.0 million pounds in February 1968 to 5.2 million pounds in March 1969. Mean monthly values each year ranged from 2.7 million pounds in 1968 to 3.6 million pounds in 1966. In 1971-74, monthly landings ranged from 1.1 million pounds in June 1974 to 3.5 million pounds in March 1971. Mean monthly landings during this 4-year period of lower values ranged from 1.8 million pounds in 1972 to 2.4 million pounds in 1971. The average monthly landing for the 10-year period was 2.83 million pounds, and 329.3 million pounds was harvested.

No Delaware landings were reported for 1965-68 and landings for 1969 and 1970 were only annual totals. Monthly values ranged from less than 0.1 million pounds in January 1971 to 1.3 million pounds in October 1971. Mean monthly values during 1969-71 ranged from 0.2 to 0.7 million pounds, averaged 0.56 million pounds, and totaled 40.2 million pounds harvested.

Maryland landings showed significant increases and decreases during the 10-year period. During 1965-70, monthly values ranged from 0.007 million pounds in December 1966 to 1.9 million pounds in June 1970. The significant increase occurred after August 1967. Mean monthly values ranged from less than 0.1 million pounds in 1968 to 1.1 million pounds in 1970. After 1970, landings declined to moderate and somewhat more stable levels. Monthly values ranged from 0.2 million pounds in November 1974 to 0.9 million pounds in February 1971; mean monthly values ranged from 0.7 million pounds in 1971 to 0.5 million pounds in 1974. The average monthly landing was 0.46 million pounds for the 10-year period, with 55.6 million pounds harvested.

Virginia landings showed the most dramatic increase. No landings of surf clams had been reported at Virginia ports before 1968, and a 0.017 million-pound quantity for August 1969 was the first. Landings of much less than 0.1 million pounds were reported for September-December 1969 and less than 0.1-0.4 million pounds for August-December 1970. These low quantities suggest that the effort was exploratory to locate beds and develop dock facilities. Thereafter, landings were made throughout the year and increased from a low of less than 0.1 million pounds for April 1971 to 5.9 million pounds for October 1974. Mean monthly values for the 4-year period ranged from 0.4 million pounds in 1971 to 4.9 million pounds in 1974 and averaged 2.72 million pounds. A total of 130.3 million pounds was harvested in the four years.

Interview Records

Interviews were conducted by one port sampler during 1965-70. Efforts were concentrated at Point Pleasant, N.J., in 1965-67 and were about equally divided between the Point Pleasant and Cape May-Wildwood, N.J., ports in 1968 (Table 4). Thereafter, and until 1972, most interview records were gathered at Cape May-Wildwood, N.J. In 1970, another interviewer began collecting records at Ocean City, Md., and thereafter visited this and Virginia ports. In total, over 16,000 interviews were accomplished during the 10-year study period.

Areas Fished

Based on interview records, the areas fished by the surf clam fleet expanded greatly during the study period. In 1965 and 1966, about 360 n.mi.[2] were fished by the New Jersey fleet, mostly off Point Pleasant (Table 5). By 1967, the areas fished increased to 510 and 470 n.mi.[2] by the Point

Table 4.—Approximate number of interview records.

Year	Number	Port interviewed most
1965	1,000	Point Pleasant, N.J.
1966	1,400	Point Pleasant, N.J.
1967	740	Point Pleasant, N.J.
1968	1,240	About equal, Point Pleasant and Cape May-Wildwood, N.J.
1969	1,950	Cape May-Wildwood, N.J.
1970	3,580	Cape May-Wildwood, N.J.
1971	2,850	Cape May-Wildwood, N.J.
1972	2,520	Cape May-Wildwood, N.J.
1973	290	Ocean City, Md.
1974	530	Ocean City, Md.
Total	16,100	

Pleasant and Cape May-Wildwood fleets, respectively. Almost one-third of the area fished by the Cape May-Wildwood fleet was off the Delaware and Maryland coasts, indicating an initial shift in effort southward. The fishing areas off New Jersey continued to expand in 1968 and 1969, but much of the increase resulted from trips to locations between the two major ports in that state.

In 1970, the Point Pleasant vessels fished a smaller area (550 n.mi.^{2}) than in the preceding 2 years, but the area covered by the Cape May-Wildwood fleet remained almost equal to that of 1969 (1,100 n.mi.^{2}). In 1970, interview records from Maryland-based vessels first became available and indicated that approximately 800 n.mi.^{2} were being fished, with activity dispersed off the entire Delmarva Peninsula. By 1971, the Point Pleasant fleet increased its area coverage to 650 n.mi.^{2}, the Cape May-Wildwood fleet activity decreased to 875 n.mi.^{2}, but the area fished by the Ocean City, Md., fleet increased greatly to 1,400 n.mi.^{2}

Interview records for vessels fishing from Virginia ports became available for the first time in 1971, and indicated that fishery operations were concentrated in a 175 n.mi.^{2} area. During 1972, the area fished by Point Pleasant vessels increased to 975 n.mi.^{2}, that of the Maryland fleet decreased to 1,000 n.mi.^{2}, and the area fished by the Virginia fleet increased to 300 n.mi.^{2} Interviews were available only from Maryland and Virginia ports in 1973, and indicated a decrease in the fishing area occupied by Maryland vessels to 725 n.mi.^{2} and no change from 1972 in the area fished by Virginia vessels. In 1974, interviews available only for April-August for Point Pleasant showed a decrease in area coverage of this fleet to 500 n.mi.^{2}. Maryland and Virginia vessels increased the areas fished to 1,225 and 525 n.mi.^{2}, respectively.

At the dock, the bags of clams are off-loaded and stacked on a pallet.

Table 5.—Estimated square nautical miles fished by vessels from ports interviewed, 1965-74

Year	Ports: Point Pleasant, N.J.	Cape May-Wildwood, N.J.	Ocean City, Md.	Several Virginia ports
1965	220	140	—	—
1966	330	30	—	—
1967	510	470	—	—
1968	640	780	—	—
1969	780	1,100	—	—
1970	550	975	800	—
1971	650	875	1,400	175
1972	975	875	1,000	300
1973	—	—	725	300
1974	500	—	1,225	525

Fleet Operations

Surf clam vessels usually operated on a day-trip basis, returning to port each evening. A few overnight trips were made, but these were the exception.

The Point Pleasant fleet fished consistently at an average depth of 71-78 feet (21.6-23.8 m) each year, within a depth range between 24 and 120 feet (7.3 and 36.6 m). Fluctuations in depths fished by the Cape May-Wildwood fleet each year were influenced by a seasonal effort to fish shoal, with inshore depths averaging 40 feet (12.2 m) during the winter months and deeper, offshore depths averaging 70 feet (21.3 m) during the summer. A depth range of 12-120 feet (3.7-36.6 m) was recorded. The Ocean City, Md., fleet fished depths averaging 45 feet (13.7 m) in 1970, but thereafter fished at average depths of 64 feet (19.5 m) each year. A depth range of 10-120 feet (3.1-36.6 m) was recorded. The Virginia fleet fished average depths of 60 feet (18.3 m) and a depth range of 30-100 feet (9.1-30.5 m).

The annual average daily effort per vessel by the Point Pleasant fleet during 1965-74 varied from 8.8 to 9.8 hours, or no more than 1 hour during the 10-year period; average daily effort for the Cape May-Wildwood fleet varied from 6.0 to 8.0 hours, or 2 hours variance; the averages for the Ocean City, Md., fleet varied from 6.1 to 8.1 hours, 2 hours variance; and the averages for the Virginia fleet varied from 6.9 to 8.9 hours, 2 hours variance (Fig. 2). There were records of trips as short as 1 hour fishing time, due usually to equipment failure, and as long as 30 hours.

A high annual average catch-per-hour value of 678 pounds was recorded for the Point Pleasant fleet in 1965, but declined thereafter and reached a low of 315 pounds in 1972 (Fig. 2). For

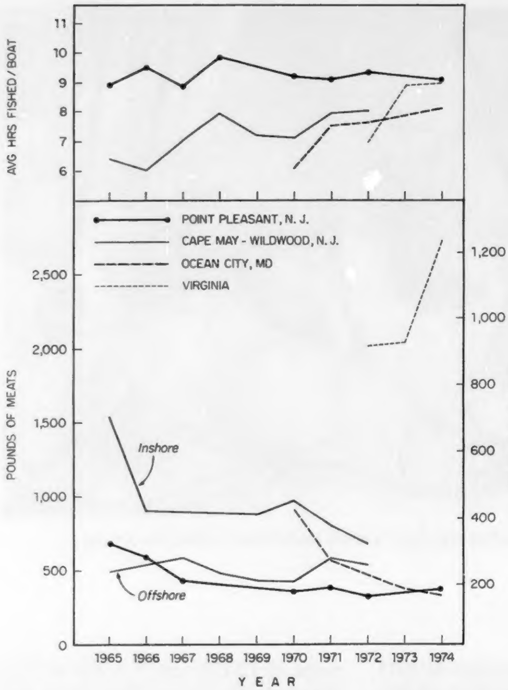


Figure 2.—Annual average daily effort and catch-per-hour of surf clams for vessels fishing from Point Pleasant and Cape May-Wildwood, N.J.; Ocean City, Md.; and Virginia ports in 1965-74.

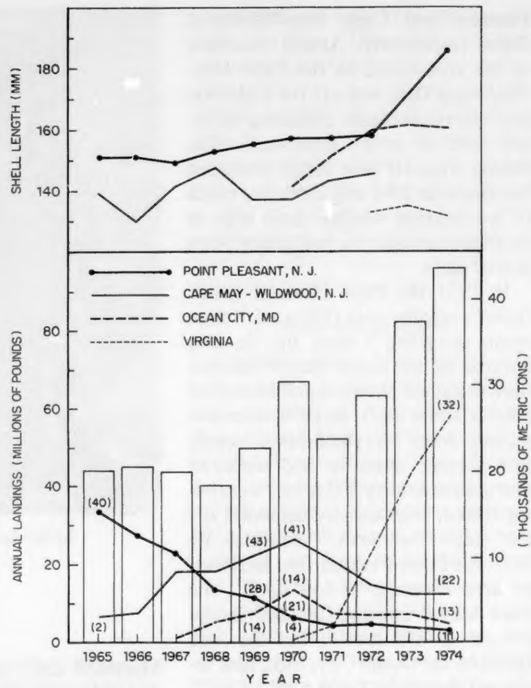


Figure 3.—Annual mean shell lengths of surf clams, millions of pounds of meats landed, and numbers of vessels (in parentheses) fishing from the Point Pleasant and Cape May-Wildwood, N.J.; Ocean City, Md.; and Virginia ports in 1965-74.

the Cape May-Wildwood fleet, the highest catch-per-hour value of 1,542 pounds was recorded in 1965 and when fishing occurred on inshore beds, but declined to a low of 680 pounds in 1972. On the offshore beds, the highest catch-per-hour value of 578 pounds was recorded in 1967 and 1971, and the lowest value of 415 pounds was recorded in 1970. A high catch-per-hour value of 901 pounds was recorded for the Ocean City, Md., fleet in 1970, but thereafter declined to 319 pounds in 1974. Average catch-per-hour values were the highest for the Virginia fleet, ranging from 2,006 to 2,737 pounds.

The Point Pleasant fleet consistently caught clams of a large average shell length each year, varying from 149 to 186 mm (5.9 to 7.3 inches) (Fig. 3). This latter mean size was higher than all others reported during the study period and included the largest specimen to date (Ropes and Ward, 1977). Minimum and maximum sizes were 105 and 226 mm (4.1 and 8.9 inches). The Cape May-Wildwood fleet caught clams of an intermediate average shell length each year, varying from 130 to 147 mm (5.1 to 5.8 inches). Annual values included clams from inshore beds, averaging 127-131 mm (5.0-5.2 inches), and clams from offshore beds, averaging 155-160 mm (6.1-6.3 inches). Minimum and maximum sizes were 95 and 195 mm (3.7 and 7.7 inches). The Ocean City, Md., fleet caught clams averaging 141-161 mm (5.6-6.3 inches) each year. The minimum and maximum sizes were 95 and 200 mm (3.7 and 7.9 inches). The Virginia fleet caught clams of the smallest average shell length each year, varying from 132 to 135 mm (5.2 to 5.3 inches). Minimum and maximum sizes were 86 and 188 mm (3.4 and 7.4 inches).

Trends, Predictions, and Major Post-Study Period Events

Long Island Fishery

The modern-day fishery for surf clams began operation during the mid-1940's in the shallow, near-shore waters from East Rockaway to Fire Island Inlets off Long Island, N.Y.

(Yancey and Welch, 1968). This same general area has been fished continuously to the present, although most of the industry moved to New Jersey by the early 1950's. After surveys were made in 1965, Ropes (1971) rated surf clam abundance off Long Island the second lowest of four Middle Atlantic Bight areas and the lowest after a survey made in 1974 (Ropes[2]). Franz (1976) conducted an intense survey off Long Island in 1974 and found surf clams most abundant from Shinnecock Inlet to Montauk Point and west of Rockaway Inlet. Although the few Long Island vessels fish in an area of low clam abundance, expansion to areas of higher abundance is unlikely. The fishery has usually avoided dredging beds west of Rockaway Inlet because of suspected contamination of the resource by effluents from New York Harbor. In 1974, these beds were closed to shellfishing, except for bait purposes, by the Food and Drug Administration (Verber, 1976). Channels to ports east of Fire Island Inlet can be hazardous to navigation by the types of vessels in the fleet, and shore-side off-loading facilities are poorly developed. These factors limit the Long Island fishery and result in relatively low, albeit stable, production. In the years 1975, 1976, and 1977, landings at Long Island ports were 4.6, 3.5, and 3.4 million pounds, respectively. Future landings may be at about the 3 million-pound level, barring significant changes in fleet composition or catastrophic environmental phenomena.

New Jersey Fishery

Industry explorations begun in 1949 located extensive beds of surf clams yielding high quantities of meats per bushel off New Jersey (Yancey and Welch, 1968). Docks were developed for landings and plants built for processing the clams in the state. The industry established itself as an important fishery by relying heavily on the New Jersey beds.

The importance of the New Jersey beds is obvious from a landing record of 195.3 million pounds in 1965-69, which accounted for 87.6 percent of the 223.0 million-pound U.S. 5-year total. During this period, however, landings at Point Pleasant showed a drastic decline from 33.5 million pounds in 1965 to 11.8 million pounds in 1969 (Fig. 3). Landings at the Point Pleasant port continued to decline and by 1974 were 3.5 million pounds, due in part to fewer vessels operating from the Point Pleasant port after 1965, but also to lower catch rates, as given earlier. Concurrently, landings at Cape May-Wildwood increased from 8.4 million pounds in 1965 to 26.1 million pounds in 1970 (Fig. 3). Thereafter landings at Cape May-Wildwood also declined to 12.6 million pounds in 1974. The increase in landings paralleled an increase in the number of vessels operating from the Cape May-Wildwood port and the decline paralleled a reduction in vessels. The reduction was effected despite an increase in the number of vessels entering the fishery, several of which were of the new and more efficient stern-dredge type. Four conditions probably influenced the reduction: 1) The declining catch rate of clams in offshore Point Pleasant beds; 2) low, but apparently stable, catch rates of clams in offshore Cape May-Wildwood beds; 3) a decline in catch rate of clams from the New Jersey inshore beds after 1970; and 4) the potential for high catch rates from unfished beds discovered during resource surveys off Delmarva Peninsula. The net result was that fewer vessels operated from New Jersey ports by 1974. Landings during 1970-74 of 134.0 million pounds at these ports comprised 37.0 percent of the U.S. 5-year total of 361.7 million pounds.

The results of biological research surveys indicated that over-exploitation of the surf clam resource has been particularly serious in the New Jersey offshore area. After surveys in 1965, Ropes (1971) rated the surf clam abundance off New Jersey the highest of four Middle Atlantic Bight areas, but only second after a survey made in 1974 (Ropes, footnote 2). More recently, Serchuk et al. (1979) reviewed surf clam survey data and landing records for 1965-77. The New Jersey offshore surf clam resource was divided into northern and southern areas. In the former area, fished mostly by vessels of the Point Pleasant fleet, a continuous and rapid downward trend in abundance and prerecruit indices was observed after 1969. An almost parallel decline in annual landings from the area reached the lowest levels for any of the areas in the Middle Atlantic Bight. In the years 1975, 1976, and 1977, landings were 4.2, 2.5, and 1.8 million pounds respectively, at the Point Pleasant port. Declines in resource abundance and landing levels in 1976 and 1977 were further exacerbated by reduced oxygen concentrations occurring in the water over the northern New Jersey beds during June-October 1976, causing extensive faunal mortalities (Sharp, 1976; Steimle and Sindermann, 1978). The NMFS Northeast Fisheries Center staff estimated that 61.5 percent of the New Jersey surf clam biomass was lost (Ropes et al., 1979).

In the southern New Jersey area, fished mostly by vessels of the Cape May-Wildwood fleet, a continuous decline in inshore stocks from 1972 onward was reported by Haskin (1978). Offshore survey indices declined after 1969 and stabilized at levels slightly higher than those for the northern area, but annual landings from it were relatively low. Landings in the years 1975, 1976, and 1977 at the Cape May-Wildwood port were 16.4, 11.5, and 16.5 million pounds, respectively.

Ocean City, Md., Fishery

The industry explorations mentioned above for the New Jersey fishery also located beds of surf clams off the Delaware and Maryland coasts (Yancey and Welch, 1968). Landings of slightly more than 0.1 million pounds of meats were reported for the first time at the Ocean City, Md., port in 1950, and a continuous, low pro-

[2]Ropes, J.W. 1975. Allowable surf clam harvest estimates—1974. Northeast Fisheries Center, National Marine Fisheries Service, NOAA, Woods Hole, MA 02543. Unpubl. manuscr.

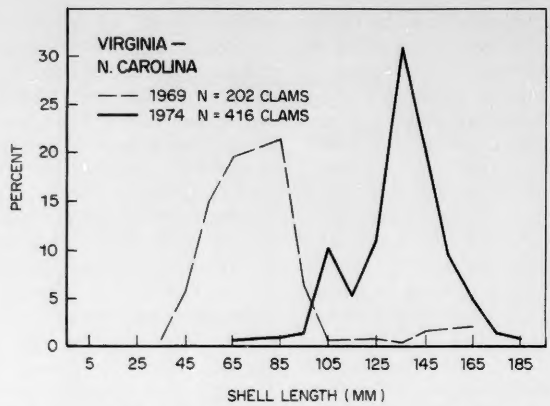


Figure 4.—Frequency distribution of surf clams by shell length in survey samples from off Virginia-North Carolina during 1969 and 1974.

duction thereafter never exceeded 2.5 million pounds until after 1967. Vessels began shifting from more northern ports to the Maryland port by 1968 and fished dense beds of surf clams north of the inlet and in Delaware waters. Shell length measurements of clams in interview records averaged 135 mm (3.5 inches) in March-July 1970, but for the remainder of the year, the fleet moved to larger clams offshore, which increased the annual average to 140 mm (5.5 inches) (Fig. 3). Landing records reached a peak of 13.7 million pounds in 1970. Subsequent landings declined to about half the peak amount, although similar fishing patterns were observed in 1971 as in 1970. Thereafter the fleet expanded southward and more to offshore beds of large clams. The Ocean City, Md., inlet water depths and dock facilities were limiting factors for some vessels which prompted expansion to more distant beds and the development of docks in Virginia. The fleet stabilized and was only one less in 1974 than in 1970 (Fig. 3). A production of 12.8 million pounds in 1965-69 was only 5.7 percent of the U.S. 5-year total, but these figures increased to 41.6 million pounds and 11.5 percent in 1970-74.

Ropes (1971) rated surf clam abundance off the Delmarva Peninsula the second highest of four Middle Atlantic Bight areas, but the highest after a 1974 survey (Ropes, footnote 2). An inshore resource was not found in a 1974 survey by Loesch and Ropes (1977). Vessels from the Maryland port fished the offshore Delmarva Peninsula area almost exclusively during the study period. A few landings by vessels of the Virginia fleet came from the southern part of the area.

Significant post-study events include landings increases at the Ocean City, Md., port from 5.4 million pounds in 1975 to 7.1 and 8.4 million pounds in 1976 and 1977, respectively. Serchuk et al. (1979) considered that survey abundance and recruitment indices had been relatively stable and moderately high during the 1965-76 period off Delmarva Peninsula, but in 1977 a sharp decline was noted. Fishing effort by vessels in the southern New Jersey and Virginia fleets probably contributed to the decline, since many had the ability to make long-range trips into this last area of relatively high-density clam beds.

Virginia Fishery

No Virginia fishery existed at the beginning of the study period, but its establishment in the early 1970's was fostered by research survey discoveries of new fishing beds off the Delmarva Peninsula. Concurrent with expansion of fishing onto more southern grounds was the development of ports for clam landings. The bulk of the Virginia landings was made at Cape Charles, Kiptopeake, Oyster, and Little Creek, since the inlet for Chincoteague was difficult for navigation by most clam vessels in the Virginia fleet. The fishery concentrated its effort in a relatively small area off Cape Henry, and catch rates of unprecedented magnitude indicated this fishery was the most intense to date (Fig. 2, 3). Although less than 1 percent of the U.S. production of surf clam meats was landed at Virginia ports in 1965-69, it increased to 36 percent during 1970-74, almost equal to the same 5-year landing record at New Jersey ports.

The potential for this tremendous production was not indicated in early survey results. Surf clam abundance was rated lowest of four Middle Atlantic Bight areas by Ropes (1971) after surveys in 1965. By 1969, a significant distributional change had occurred; research survey abundance indices in 1969 in the Virginia area were tenfold higher than during 1965-66 (Serchuk et al., 1979). The 1969 survey data indicated a recent settlement of small clams east of Virginia and Currituck Beaches at 44-102 feet (13.3-31.1 m) depths and 3-30 n.mi. (5.6-55.6 km) from shore. Measurement data indicated that most (76.3 percent) of these clams ranged from 66 to 99 mm (2.6 to 3.9 inches) in shell length, with a modal length of 85 mm (3.3 inches), corresponding to 2- and 3-year-old clams by the age-length relationships presented in Loesch and Ropes (1977) (Fig. 4). In a 1974 survey, 73.1 percent of the clams from this area ranged from 121 to 149 mm (4.8 to 5.9 inches) long, with a modal length of 135 mm (5.3 inches) corresponding to 7-year-old clams by the age-length relationship presented in Loesch and Ropes (1977). This modal length was also the average size of clams landed at Virginia ports in 1974, given earlier.

The major post-study period conclusion about this fishery is that the

Virginia resource could not sustain the heavy rates of effort after 1974. In the years 1975, 1976, and 1977, landings were 39.1, 14.1, and 15.8 million pounds, respectively, at Virginia ports, much lower than the peak landing of 58.2 million pounds in 1974. In the review by Serchuk et al. (1979), the most recent (1976) survey indices indicated clam abundance in the Virginia-North Carolina area was low and recruitment was the lowest of any area. Future harvests are expected to be minimal from the area.

New England Region

Surf clams had an early history of use as a food in the New England region and were eaten by the Indians, colonial settlers, and beach visitors (Thoreau, 1834; Goode, 1887; Parker, 1971). A small fishery was organized on Cape Cod during the 1970's to supply bait for the cod fishery (Yancey and Welch, 1968). Thereafter, levels of production were sporadic and low. The more accessible and favored soft- and hard-shelled clams *(Mya arenaria* and *Mercenaria mercenaria)* generally supplanted utilization of surf clams in the region.

During the study period, surf clam landings ranged from much less than 0.1 million pounds in 1965 to almost 0.3 million pounds in 1971 (values not shown in Figure 1 because of the low production). Landings in 1975 and 1976 were also low (about 0.1 million pounds), but increased significantly in 1977 to almost 1.1 million pounds (USDOC, 1979). An interest exists for a surf clam fishery in the region. A few high-density locations were found during surveys off southern New England, but the bottom was hazardous for dredging and the densities of clams appear too localized and sporadic to sustain a fishery comparable to that in the Middle Atlantic region.

Worldwide and U.S. Clam Fisheries

Even with the increased production of surf clams during 1965-74, the United States was second in the world to Japan in landing the largest quantities of clams (NMFS, 1975; FAO, 1975). Japan consistently leads the world in catching the largest poundage of molluscan shellfish, such as squid, cuttlefish, octopus, several species of clams, oysters, and snails; but the United States is first in harvesting bivalve mollusks such as clams, oysters, and scallops (Merrill and Ropes, 1977). These latter resources are far greater on the Atlantic than Pacific coast (Merrill and Ropes, 1971), partly owing to the large area for shellfish beds in the substrata of Georges Bank and the Middle Atlantic continental shelf.

Many Atlantic coast estuaries contain habitats for soft- and hard-shelled clams *(Mya arenaria* and *Mercenaria mercenaria),* two species that were the traditional sources of clam meats since colonial days (Tiller et al., 1952; Hanks, 1963; McHugh, 1977; Ritchie, 1977). During the study period, landings from the soft-shelled clam fishery ranged from 8.6 to 13.5 million pounds and averaged 11.0 million pounds annually; landings from the hard-shelled clam fishery ranged from 14.5 to 16.7 million pounds and averaged 15.5 million pounds (Fig. 5). Of the total United States clam meats landed, soft-shelled clams amounted to a low 7.9 percent in 1974 and a high 16.7 percent in 1968; hard-shelled clams comprised a low 12.1 percent in 1974 and a high 22.7 percent in 1967. Landings from the surf clam fishery ranged from 40.6 to 96.1 million pounds and averaged 58.6 million pounds during the study period, supplying more than 60 percent of the United States total clam meats, averaging 61.8 percent annually in 1965-69 and 71.8 percent in 1970-74. The peak 96.1 million pounds landed in 1974 supplied 79.0 percent of the U.S. total.

The post-study events indicate that increases in clam supplies from the above fisheries are not imminent in the near future. In fact, sizable decreases in surf clam landings during 1975, 1976, and 1977 equaled 9.6, 48.9, and 46.9 percent fewer pounds of meats, respectively, than the peak 1974 landing; but soft- and hard-shelled clam landings remained relatively stable (Fig. 5). It is important to note that the

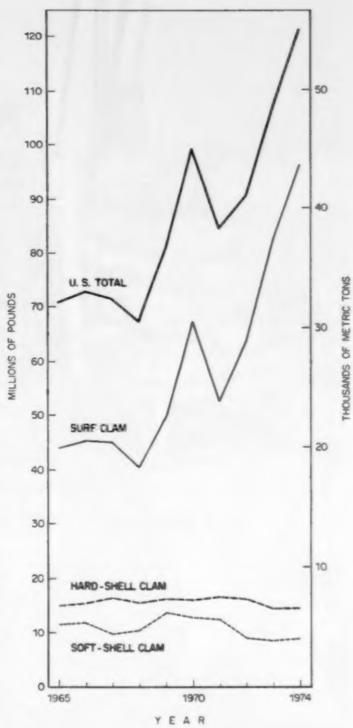


Figure 5.—Annual landings of the meats of soft-shelled, *Mya arenaria*; hard-shelled, *Mercenaria mercenaria*; and surf clams, *Spisula solidissima*, and total U.S. clam-meat landings, 1965-74.

lower landings of surf clams in 1975 and 1976 were made before annual quota limitations were in effect under a fisheries management plan for the surf clam resource (USDOC, 1977, 1979).

In recognition of probable future decreases in surf clam supplies, the industry increased the utilization of the ocean quahog, *Arctica islandica*, resource. Rhode Island has had a fishery for this bivalve for about three decades, but annual production was less than or equal to 2 million pounds (Ropes, 1979). The species has a far greater geographic distribution than surf clams, occurring along the east coast of North America north of Cape

Fork-lifting a pallet for movement into the shucking plant.

A modern stern-dredge clam vessel.

Hatteras, around Iceland and the Faroe Islands, and on the European continental shelf. Ocean quahogs were most frequently taken in survey samples at 120-240 feet (36.7-73.2 m) depths in the Middle Atlantic Bight and were most abundant and nearer to shore off Long Island and New Jersey. Surf clam dredges can be quickly converted to harvest ocean quahogs, and the processing plants have developed several marketable products for the meats. Landings of 5.7 and 16.5 million pounds in 1976 and 1977, respectively, were dramatic increases over previous records and most (71-83 percent) of this production was landed at New Jersey ports. The species is included with surf clams in a management plan to regulate harvesting (USDOC, 1977, 1979).

General Comments

The early history of the surf clam fishery was characterized by sporadic operations producing low levels of landings. After a developmental period from 1943 to 1949, the principles of the hydraulic dredge and processing technology had been discovered, giving impetus to the establishment of an important fishery in the northern half of the Middle Atlantic Bight. From 1950 to 1965, landings of surf clams increased mostly at New Jersey ports, although ports on Long Island, N.Y., and in Maryland were also active. By 1960 and thereafter, the volume surpassed landings of the two traditional hard- and soft-shelled clam species. Clearly the products from the surf clam resource had gained acceptability in the market to fill the demand for clam meats.

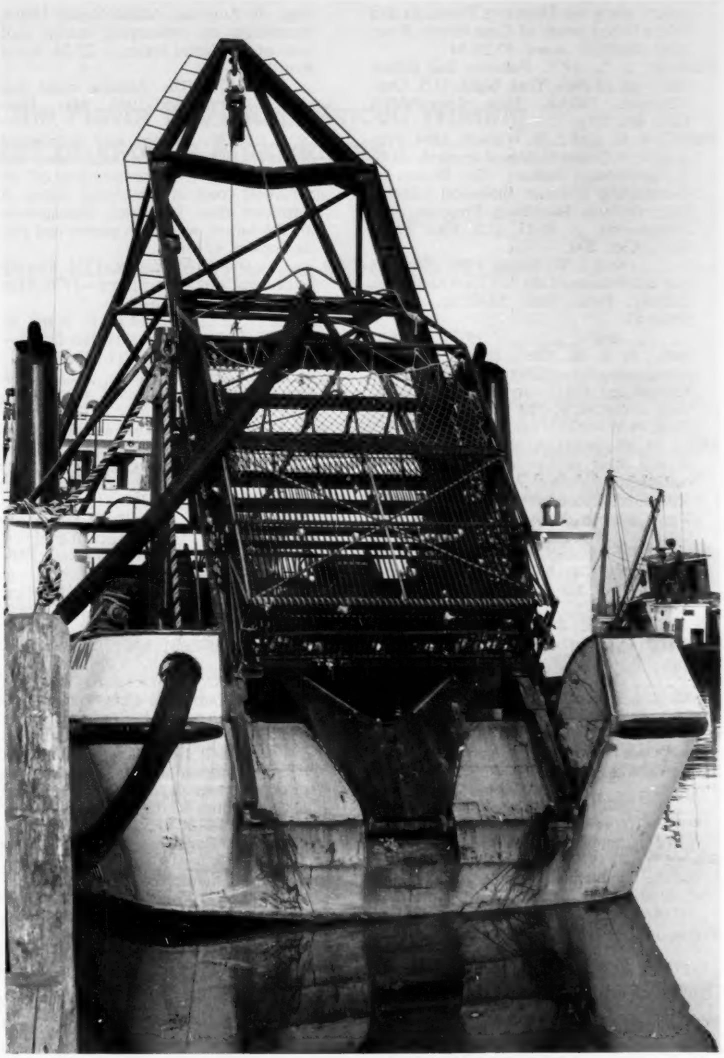
Interviews of vessel captains taken from 1965 to 1974 recorded information about trip operations during a period of expansion of the fishery into most of the southern half of the Middle Atlantic Bight. The tremendous increase in intensity of fishing effort on previously unfished beds coincided with an observed decline in the offshore New Jersey resource, although considerable effort continued on the inshore resource. Improvements in vessel harvesting capabilities and processing technology resulted in landings during 1970-74 greater than had ever been seen in the fishery.

Landings declined after 1974, and low levels of resource abundance were primarily attributed to overfishing. Improvements in vessel and harvesting capabilities have continued to occur,

but continued unrestricted harvesting has been considered detrimental to the economic viability of this important fishery. To address these concerns, a Fishery Management Plan for Surf Clams was developed by the Mid-Atlantic Regional Fishery Management Council and implemented by the Secretary of Commerce in November 1977 (USDOC, 1977, 1979).

Acknowledgments

Many people contributed to the annual reports which form a basis for this summary report. Authors of annual reports are acknowledged as such in the literature cited section, but others, such as John A. Prescott, Alva E. Farrin, Michael Krautheim, David L. McQuay, and David Townsend, collected interview records or assisted in data analyses. Francis Riley, Program Leader for the Division of Statistics and Market News, Northeast Region, and agents William E. Brey at Easton, Md., and Eugene A. LoVerde at Toms River, N.J., provided landing records. Special thanks are due captains and crews of vessels and industry personnel and representatives too numerous to name individually. They voluntarily provided the basic data for the reports. Fredric M. Serchuk critically reviewed the manuscript.



Stern view of ramp and hydraulic clam dredge.

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Stabilization of the Flavor of Frozen Minced Whiting I. Effect of Various Antioxidants

JOSEPH J. LICCIARDELLO, ELINOR M. RAVESI, and MICHAEL G. ALLSUP

Introduction

It is an established fact that intact fish muscle such as would exist in a fillet or whole fish is usually more susceptible to the development of oxidative rancidity during frozen storage when compared with meat or many other foods. This is due to the high content of unsaturated fatty acids and also to their relatively high degree of unsaturation compared to other natural fats and oils (Lovern, 1956; Olcott, 1962).

The lipids of marine fish contain fatty acids usually ranging in chain length from 14 to 22 carbon atoms. A high percentage (60-75) of these fatty acids are unsaturated, some having up to 6 double bonds (Stansby, 1967). The unsaturated fatty acids, and particularly the polyunsaturated ones, readily react with oxygen in the presence of an activator or catalyst, setting off a chain reaction to form hydroperoxides that degrade to carbonyl compounds which are responsible for the rancid odors and flavors. This reaction is often referred to as autoxidation (Lundberg, 1954). Another type of rancidity occurs when fatty acid-containing esters are hydrolyzed, liberating the free fatty acids. This condition is termed hydrolytic rancidity, and is readily detected by the senses when unpleasant-smelling, small-chain fatty acids such as butyric, caproic, and caprylic are involved. However, this paper will not be concerned with hydrolytic rancidity.

The rancid odors or flavors of oxidized fish oil have been described in terms such as musty, turnipy, fishy, painty, cold storage flavor, etc., and are generally distinct from rancid vegetable and animal fats which have been usually characterized as tallowy or cardboardy (Banks, 1967; Baines et al., 1969). Oxidation of lipids can also result in a yellow-to-brownish discoloration in fish, known as rusting. In carotenoid-pigmented fish, such as salmon or ocean perch, a fading of the red skin color may occur (Tarr, 1947; Dyer et al., 1956). A comprehensive review of the kinetics of lipid oxidation has been presented by Labuza (1971).

The lipids are present as phospholipids which are associated intracellularly with the mitochondria, and also as depot fats (mainly trigylcerides) stored in the muscle, mesentary, and the viscera, particularly the liver. A small portion of the lipid fraction consists of unsaponifiable matter which is predominantly sterols with lesser amounts of hydrocarbons, fat-soluble vitamins, carotenoid pigments, wax esters, etc. (Tsuchya, 1961). The susceptibility of a particular fish flesh to oxidative rancidity is related to intrinsic factors such as lipid content and degree of unsaturation, season, feed, fishing ground, stage of spawning cycle, stage of maturity, content of prooxidants and antioxidants; and to extrinsic factors such as storage temperature and partial pressure of oxygen (Castell and MacLean, 1964; Ackman, 1967; Labuza, 1971). The lean fish (≤ 1 percent lipid), although not as prone to becoming rancid compared with fatty fish (≥ 5 percent lipid), still can develop this condition because of the highly unsaturated nature of their lipids which consist predominantly of phospholipids and lipoproteins. The phospholipid content of the muscle of various marine species has been shown to range from about 0.5 to 0.7 percent (Lovern, 1962). Thus, in lean fish the phospholipids constitute the major portion of the total lipids. Fatty fish also contain phospholipids, but in addition contain deposits of depot fat usually located just beneath the skin and along the lateral line in the form of red or dark muscle which is rich in hematin compounds (hemoglobin, myoglobin, cytochromes). The latter class of compounds are known to be potent catalysts for lipid oxidation (Lew and Tappel, 1956; Watts, 1954; Brown et al., 1957). Semifatty fish (1-5 percent lipid) would be intermediate between lean and fatty fish in susceptibility to oxidative spoilage.

Some fisheries, such as the Atlantic whiting, *Merluccius bilinearis* (also known as silver hake), have not been exploited to their fullest potential because of some inherent characteristics which preclude the economical filleting of the particular species. These characteristics include excessive bones, small size, irregular shape, soft flesh, etc. With the employment of meat-bone separators, an efficient recovery of minced flesh can be attained from these types of fish (King and Carver, 1970; Miyauchi and Steinberg, 1970).

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During mincing, however, changes occur or conditions are created conducive to the development of oxidative rancidity, and these include 1) a breakdown of the integrity of the musculature to a smaller particle size, 2) disruption of cells with release of enzymes and prooxidants such as the heme substances, 3) distribution of the localized dark muscle throughout the entire mass of minced flesh, and 4) intimate contact of air with an increased surface area of muscle tissue.

In a study with paired whiting fillets on the effect of mincing on oxidation of the tissues, we observed the TBA[1] number to approximately double as a result of the mincing treatment (unpublished data, NMFS Gloucester Laboratory, Gloucester, Mass.). Flink (1978) reported that this increase was prevented when the whiting was minced in a nitrogen atmosphere. However, sparging minced mullet with nitrogen immediately after mincing in the presence of oxygen was ineffective (Lee and Toledo, 1977). Apparently once oxygen becomes attached to reactive sites it becomes difficult to remove. If the deboning machine contains iron or other catalytic metal surfaces which contact the fish, the TBA value of the flesh may increase (Lee and Toledo, 1977). Silberstein and Lillard (1978) observed an increase in hemoglobin and nonheme iron in minced mullet as a consequence of mechanical deboning.

Thus, because of these changes in physical constitution, one would theoretically expect minced fish to be more readily predisposed to spoilage from oxidative rancidity during frozen storage compared with fillets. Crawford et al. (1972) confirmed this with Pacific whiting, and Hiltz et al. (1976) also reported evidence of rancidity in minced silver hake during storage at -10°C (14°F). It should be pointed out, however, that this phenomenon was not observed with minced kipper (herring) fishsticks compared to whole kippers (Cole and Keay, 1976).

The following average lipid contents have been reported for the edible portion of Atlantic whiting: 1.2 ± 0.3; 2.0 ± 0.7; 1.9 (respectively, Sidwell et al., 1974; Brooke et al., 1962; Bean et al., 1937). Hiltz et al. (1976) found an average lipid content of 2.95 percent for fillets of summer-caught Atlantic whiting (which they stated was higher compared with winter-caught fish); however, the average lipid content of mince prepared from the same batch of fish was 2.20 percent. The lesser lipid content for the mince was attributed to removal of more subcutaneous fat by mechanical deboning, compared with hand filleted flesh.

We analyzed Atlantic whiting flesh for lipid content by methanol-chloroform extraction (Bligh and Dyer, 1959) at approximately monthly intervals over a 12-month period and found a range in mean lipid content of 1.6 to 3.2 percent (unpublished data, NMFS Gloucester Laboratory). Individual fish ranged in fat content from about 0.7 to 5.0 percent. The reasons for this natural variability have been cited (Jacquot, 1961); however, sampling errors are constantly present, due to anatomical differences in lipid composition.

In Atlantic whiting the dark muscle was found to contain 14.5 percent lipid, compared to 0.91 percent for the light muscle (Hiltz et al., 1976). Thus, unless the sample taken for analysis contains light and dark muscle in natural proportion, errors can occur in the lipid quantification. Although Atlantic whiting at times could be classified as a lean fish or fatty fish, in most instances it would be regarded as a semifatty fish and, as such, would be intermediate in susceptibility to lipid oxidation. Seventy-five percent of the fatty acids of Atlantic whiting were found to be unsaturated, and of these an abundant amount (38 percent) consisted of C20:4, C20:5, and C22:6 (Bonnet et al., 1974). Labuza (1971) indicated that the C20:5, C22:4, and C22:6 fatty acids of phosphatydyl ethanolamine are especially prone to becoming oxidized and are probably the primary cause of initial changes leading to rancidity in lean fish. Thus the necessary constituents for oxidative rancidity are present in Atlantic whiting.

There are several alternative methods for retarding lipid oxidation in frozen minced fish. Storage at low temperatures would probably be the simplest, because no additional process treatment is required and this method would be applicable to all product forms (Dyer et al., 1956; Cole and Keay, 1976). Labuza (1971) has stated that lipid oxidation proceeds rapidly at temperatures within the range of 0° to -18°C (32° to 0°F) with a maximum oxidation rate at about -4°C (25°F). Below -18°C, the rate of lipid oxidation decreases rapidly. However, a low storage temperature, although very effective, would not be a reliable method of stabilizing quality because of loss of temperature control once the product entered the distribution channel.

Packaging under vacuum (Liljemark, 1964; Sacharow, 1969; Hansen, 1972; Bilinski et al., 1979) or in an inert gas (Tarr, 1948) in an oxygen-impermeable film has been demonstrated to be an effective means of suppressing rancidity development in frozen fish; however, this treatment does not provide any protective carry-over when the primary product is converted into secondary products. The economics of vacuum-packing processed products such as breaded fish sticks could also be prohibitive. Glazing whole fish, fillets, or steaks has been used with success and is especially effective if the glaze contains an antioxidant (Tarr, 1948; Bilinski et al., 1979). The deficiency with this control method is that the glaze has to be periodically replenished because of sublimation, and cracks in the glaze due to freezing rate could also reduce its effectiveness (Flink, 1978). In addition, glazing would not be compatible with batter/breaded products. Saberizing or deep-skinning to remove the subcutaneous fatty tissue along the lateral line has been found effective for stabilizing hake fillets (Licciardello et al., 1980). However, applying this treatment to

[1]Abbreviations used in this manuscript: TBA = Thiobarbituric acid; EDTA = Ethylenediamine-Tetraacetate; BHA = Butylated hydroxyanisole; TBHQ = mono-tertiary-butylhydroquinone.

underutilized fish species destined to be minced would defeat the original purpose of mincing from an economic standpoint. Washing to remove lipids, blood, and other prooxidants has aided in improving color and flavor stability of minced fish (Miyauchi et al., 1975), but there is a loss of soluble protein from this treatment and, some researchers believe, adverse texture changes during frozen storage. Application of oxygen scavengers such as the glucose oxidase-glucose system (Liljemark, 1964; Kelley, 1971; Atkinson and Wessels, 1973) or the scavenger pouch, Maraflex[2] 7 F (Zimmerman et al., 1974), has been advocated; however, there is a paucity of information on the efficacy of the scavenger pouch, and the glucose-oxidase treatment requires a certain processing protocol that raises doubts as to its economic feasibility for stabilizing flavor of minced fish.

There are numerous reports in the scientific literature on the efficiency of antioxidants for minimizing effects of lipid oxidation in frozen fish (Tarr, 1947, 1948; Tarr and Cooke, 1949; Banks, 1952; Farragut, 1972; Sweet, 1973). Controlling oxidative flavor changes in frozen minced fish through addition of antioxidants offers several advantages. The antioxidant could be incorporated into the mince by slowly mixing in a food mixer or applied as a controlled spray inside the drum of the deboner as the minced fish is being extruded through the perforations on the drum. This treatment should not be as costly as vacuum packaging and would provide carry-over protection into secondary products prepared from the mince.

Therefore, the purpose of this investigation was to compare the efficacy of several antioxidants in stabilizing the flavor of frozen minced Atlantic whiting.

Experimental Methods

Freshly landed Atlantic whiting, *Merluccius bilinearis,* were obtained from a Gloucester processor. The fish were scaled and then passed through a Model 22 LaPine gutting machine which had been modified (Mendelsohn et al., 1977) to automatically process whiting by heading, gutting, removing kidney and black belly membrane, and washing the gut cavity. Minced whiting was produced by passing the dressed fish through a Bibun mechanical deboner equipped with a drum having 5 mm perforations. When not being machine-processed, the fish or mince were kept well-iced to maintain a low product temperature.

Twenty-two pounds (10.0 kg) of minced fish were placed in a 28-quart (26.5 l) stainless steel mixing bowl of a Univex Mixer Model M1222. One-half pint (220 ml) of an antioxidant solution was sprayed on the fish with an atomizer over a 3-minute period while the mixing blade was rotating in an orbital path at the low speed setting.

The various antioxidant treatments included: 1) 500 ppm disodium EDTA, 2) 0.84 percent FP-88E (Freez-Gard), 3) 0.15 percent sodium erythorbate, 4) 15 or 75 ppm Tenox A (BHA + citric acid in propylene glycol, 5) 30 or 150 ppm Tenox 20 (TBHQ + citric acid in propylene glycol, and 6) 30 or 150 ppm Tenox S-1 (propyl gallate + citric acid in propylene glycol).

The two different concentrations for each of the phenolic antioxidant treatments represent the maximum permissible level and five times that amount. The maximum permissible level is 0.02 percent based on the fat content which for whiting was regarded as 3 percent. The water-soluble antioxidants were dissolved in distilled water. The phenolic antioxidants (BHA, TBHQ, and propyl gallate) had to be emulsified in a mixture of propylene glycol and distilled water (1:3) by means of a blender. Two different control samples were included in the study: One was prepared directly from the mince with no further treatment; for the other control, the mince was subjected to a 3-minute water spray-mixing process to determine the effect of the agitation received during mixing on the development of rancidity. One final test sample was prepared with 0.5 percent crab seasoning (Baltimore Spice Co.) and 3.2 percent dry, textured vegetable protein.

For each treatment a 16.5-pound (7.5 kg) block and several 5-pound (2.3 kg) blocks were formed under pressure in an Amerio plate freezer. The larger block was cut into sticks which were batter/breaded, blanched for 30 seconds in vegetable oil at 400°F (204.5°C), frozen, then packaged in 1-pound (0.45 kg) waxboard cartons and stored at 20°F (−6.7°C). The smaller blocks were stored intact in a waxboard carton at 20°F (−6.7°C) and processed into breaded sticks for organoleptic evaluation at the time of testing.

At periodic intervals the sticks or blocks were removed from storage and tested by both sensory and chemical methods for degree of rancidity. All chemical analyses were conducted in duplicate on the flesh of the uncooked fish stick after the breading was removed.

Sensory Evaluation

The frozen sticks were cooked for 15 minutes in a convection oven at 400°F (204.5°C), and with breading removed were rated by a 6-member trained panel for flavor (rancidity) on a scale of 1 to 5. Descriptive terms corresponding to numerical scores were as follows: 5 = not rancid, 4 = barely detectably rancid, 3 = slightly rancid, 2 = moderately rancid, 1 = strongly rancid. A reference control stored at −22°F (−30°C) was included in each taste test.

Peroxide Value

Peroxide value was determined on a chloroform-anhydrous sodium sulfate extract of the flesh by an iodine titration procedure described by Riemenschneider et al. (1943).

TBA Number

For determining TBA reactive substances, the method of Yu and Sinnhuber (1957) was modified by the addition of EDTA and propyl gallate to prevent oxidation during blending. TBA number was calculated by the procedure reported by Sinnhuber and Yu (1958).

[2]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Statistical Analysis

All analyses were performed on a Hewlett-Packard 97 programmable desk calculator.

Results

Tables 1 and 2 present average peroxide values and TBA numbers of the minced whiting sticks as effected by the various additives during storage at 20°F. For most treatments the decrease in flavor score (or increase in rancidity) during storage progressed at two different rates—that is, a rapid rate during the first several weeks followed by a slower rate during the remainder of the storage period. With the controls, the flavor scores reversed their downward trend and began to increase during this second phase, whereas with the samples treated with those additives that proved to be ineffective, the flavor scores remained relatively stationary during this period. A possible explanation for this phenomenon is that some particular compound that was chiefly responsible for the rancid flavor had reached its maximum concentration during the early weeks of storage and was later either entering into other reactions or was somehow being dissipated, possibly during cooking. It should be noted, however, that for those treatments that exhibited this flavor score inversion, the peroxide values and TBA numbers increased steadily throughout storage. A rational explanation for this anomaly is that the chemical analyses were performed on uncooked samples, whereas the sensory evaluation was carried out on cooked samples.

Ke et al. (1976) stated that "rancidity could be defined as the presence of off-flavors which makes the fish unacceptable to the consumer. However, many different mechanisms operative in fish muscle produce various types of off-flavors, and the responsible compounds which develop in frozen mackerel have not been fully developed." This sentiment is applicable to many other species including whiting. The taste panelists, after having rated the samples for rancidity, were requested to indicate on the score form whether the samples were acceptable, borderline, or unacceptable. In most cases the samples were considered of marginal quality when rated 3, which corresponded to slightly rancid. In accordance with this criterion, the most effective antioxidant treatments were judged to be 150 ppm Tenox S-1, crab seasoning, 0.15 percent sodium erythorbate, and 150 ppm Tenox 20.

Flavor score (rancidity rating) was correlated with TBA number and also with peroxide value on pooled data for all treatments up to and including the first 8 weeks of storage. It was not considered valid to include data beyond 8 weeks in view of the drastic change in flavor scores for some treatments during that period. The correlation coefficient (r) for regression of TBA number on flavor score was determined to be 0.70 for $n=60$. The TBA number corresponding to borderline acceptability was determined from the regression line to be 5. This numerical value is in accord with a TBA number of 4 reported for marginal quality seafood (Sinnhuber and Yu, 1958) and a number of 6 for mackerel which has lost quality (Ke et al., 1975).

Flavor score was also correlated with peroxide value over the first 8 weeks of storage, and a correlation coefficient of 0.60 was obtained. The regression line predicted a peroxide value of about 5 to be associated with a flavor score of 3.

Table 3 compares various antioxidant treatments on the basis of induction period and times to reach a peroxide value of 5, a TBA number of 5, and a flavor score of 3. The efficacy of

Table 1.—Effect of various additives on peroxide value of breaded minced whiting sticks stored at 20°F.

	Weeks in storage										
Additive	0	2	4	6	8	10	12	14	16	18	20
Control	3.5	5.5	4.7	3.3	6.2	9.7	9.1	6.6	16.4	10.9	14.5
Water control	2.9	2.7	4.2	6.3	3.8	5.3	4.9	6.6	7.2	8.1	8.3
0.15% Erythorbate	2.8	3.8	3.7	4.3	2.2	1.9	1.2	0.6	1.7	2.5	3.0
500 ppm EDTA	3.6	3.5	5.1	7.5	11.1	7.6	9.2	10.1	9.8	9.6	11.2
0.84% FP-88E	3.3	4.1	2.9	4.9	5.5	2.7	2.9	2.8	2.8	5.9	3.6
15 ppm TENOX-A	2.7	2.2	4.3	5.2	5.5	5.9	7.3	7.7	8.7	11.6	11.2
75 ppm TENOX-A	3.0	3.3	2.8	3.3	10.0	13.3	10.3	11.4	12.6	15.1	15.5
30 ppm TENOX-20	3.9	4.7	4.1	3.9	6.0	5.2	7.5	7.8	9.8	14.1	16.0
150 ppm TENOX-20	3.6	3.5	1.7	3.0	5.4	2.9	2.9	4.3	5.6	5.9	8.8
30 ppm TENOX-S-1	3.0	4.7	1.8	2.9	4.6	6.5	8.5	9.1	11.5	14.7	14.4
150 ppm TENOX-S-1	3.8	3.0	2.7	2.5	2.9	4.0	4.9	5.2	8.7	10.1	10.0
Crab seasoning	3.5	5.5	4.7	2.4	5.6	7.1	8.6	6.6	16.4	10.9	14.5

Table 2.—Effect of various additives on TBA number of breaded minced whiting sticks stored at 20°F.

	Weeks in storage												
Additive	0	2	4	5	6	8	9	10	12	14	16	18	20
Control	2.73	4.23	7.52	5.65	5.69	6.20	7.80	7.66	7.53	7.14	8.65	8.55	8.08
Water control	4.94	5.17	5.83	5.22	6.20	6.53	6.95	10.72	5.13	7.43	8.27	8.88	7.00
0.15% Erythorbate	2.59	1.18	0.61	1.32	1.08	1.69	2.82	2.30	2.11	2.21	2.87	3.01	2.54
500 ppm EDTA	1.22	3.34	9.35	6.77	6.76	5.69	6.44	4.75	5.03	5.88	7.52	5.78	6.49
0.84% FP-88E	2.59	2.82	3.62	1.65	2.35	3.67	3.39	2.26	3.43	4.51	7.38	6.49	4.28
15 ppm TENOX-A	3.76	4.23	5.31	4.55	6.02	7.38	6.82	6.63	7.16	8.51	10.25	10.39	8.23
75 ppm TENOX-A	2.12	1.93	2.16	3.05	3.38	4.84	4.23	5.31	5.78	6.39	8.32	8.41	7.47
30 ppm TENOX-20	0.75	3.06	4.32	5.41	3.67	5.83	7.05	5.50	8.85	7.00	7.47	9.64	7.05
150 ppm TENOX-20	1.18	1.55	1.88	1.74	1.03	1.60	2.77	3.29		3.59	5.36	5.69	4.28
30 ppm TENOX-S-1	0.52	2.59	3.71	4.33	2.59	4.61	5.69	4.70		7.47	11.05	9.49	11.99
150 ppm TENOX-S-1	0.94	2.16	1.97	2.40	1.41	2.30	3.10	2.30	2.68	4.51	5.50	4.84	5.78
Crab seasoning	3.06	4.98	6.96	4.09	4.04	6.67	8.26	7.38	7.90	10.53	9.87	10.58	11.61

an antioxidant treatment is usually derived from its ability to extend the induction period. In this study, induction period was defined as the time in weeks during storage at which the curve for peroxide value showed a definite change (increase) in slope. With some treatments, there did not appear to be a definitive induction period—that is, the peroxide values progressively increased from the start. On the basis of the four parameters under comparison, the most effective flavor-stabilizing treatments were considered to be 0.15 percent erythorbate, 150 ppm Tenox 20, 150 ppm Tenox S-1, and 0.84 percent FP-88E. The mixing operation did not seem to enhance the development of rancidity, since both controls became unacceptable at approximately the same time.

The phenolic antioxidants were generally ineffective when used at the maximum permissible level, but were effective at 5 times that concentration. The problem with using phenolic antioxidants as flavor protectors in foods is not necessarily rooted in their efficacy, but rather in the uniformity of incorporation. In a nonhomogenous food mass such as minced fish, it is difficult to evenly disperse a very small amount of antioxidant, especially when the solubility in the substrate is not favorable. On the basis of sensory analysis, the crab seasoning seemed to stabilize flavor during storage; however, the chemical tests indicated that these treated samples became rancid at a time comparable to the controls. The seasoning apparently masked the rancid flavor.

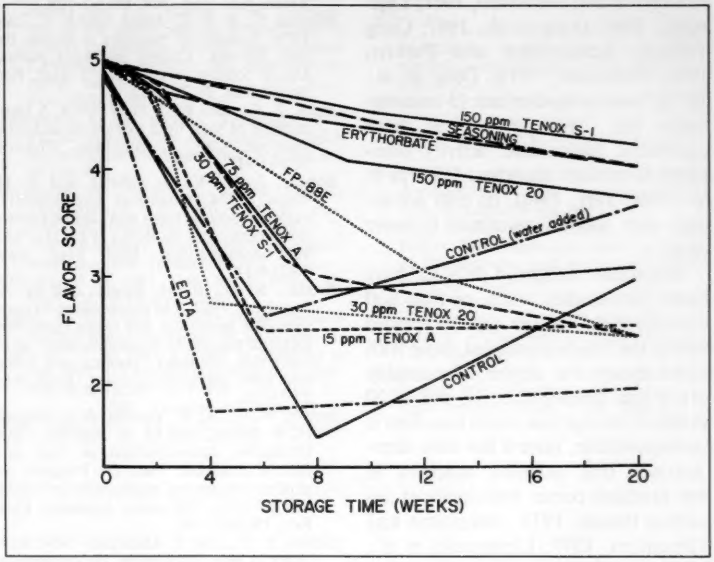

Figure 1.—Effect of various antioxidant treatments on flavor score of minced whiting sticks during storage at 20°F.

Table 3.—Effect of various additives on three parameters relating to quality (flavor) deterioration in frozen minced whiting sticks

Treatment	Induction period (weeks)	Time (weeks) to reach: P.V.[1] = 5	TBA[2] no. = 5	Flavor score = 3
Control	0	7	3	4-5
Control (water added)	2	8	1	4-5
0.15% Erythorbate	>20	>20	>20	>20
500 ppm EDTA	0	2-3	3-4	2-3
0.84% FP-88E	>20	>20	15-16	12
15 ppm TENOX-A	2	6-7	3	4-5
75 ppm TENOX-A	6	7	10	7-8
30 ppm TENOX-20	6	8	7	4-5
150 ppm TENOX-20	12	15-16	18	>20
30 ppm TENOX-S-1	6	8	8	7-8
150 ppm TENOX-S-1	9	12-13	17	>20
Crab seasoning	0	8	3	>20

[1]P.V. = peroxide value
[2]TBA = Thiobarbituric acid

EDTA at the level used behaved as a prooxidant. Variable results have been reported in the literature on the efficiency of EDTA in combatting oxidative rancidity. Some investigators have found it to be effective (Farragut, 1972; Sweet, 1973); others concluded it to be ineffective (Deng et al., 1977; Iredale and York, 1977). It is generally considered that EDTA is only useful in controlling rancidity when trace catalysts such as iron or copper are present, and in their absence EDTA exerts no protective action. There is also evidence to suggest that EDTA may form complexes with increased catalytic activity, and this phenomenon could account for the prooxidant effect observed in this study.

It would thus appear that of the various antioxidants examined in this study the erythorbate and the FP-88E were the most effective from a practical standpoint. FP-88E is a commercial preparation containing sodium erythorbate, polyphosphates, and sodium chloride. However, the latter compound is considered to be a prooxidant. Therefore, sodium erythorbate was selected as the antioxidant of choice for further investigation on the basis that it is on the FDA's GRAS list, is water soluble and, therefore, easily incorporated, and is highly efficient for the intended purpose. Whereas the phenolic antioxidants are probably true antioxidants in that they interrupt free-radical chain reactions by donating electrons or hydrogen, sodium erythorbate or ascorbate function as an oxygen scavenger (Cort, 1974). The application of sodium erythorbate for controlling rancidity development in fish has been reported (Iredale and York, 1977; Bilinski et al., 1979); however, more feasibility studies have been conducted with ascorbic acid or sodium ascorbate (Tarr, 1947, 1948;

Andersson and Danielson, 1961; Liljemark, 1964; Greig et al., 1967; Greig 1967a,b; Bauernfeind and Pinkert, 1970; Orthoefer, 1973; Deng et al., 1977). Sodium erythorbate (d-isoascorbate) has been shown to have equivalent antioxidant activity compared to sodium ascorbate (Yourga et al., 1944; Tarr, 1948). Its only advantage over sodium ascorbate is lower cost.

The results presented thus far have been for studies with oil-blanched breaded sticks. In the case of minced blocks the results paralleled those with sticks except the degree of rancidity which had developed at the end of 20 weeks of storage was much less. This is understandable, since it has been demonstrated that oxidative rancidity in fish products occurs principally at the surface (Sweet, 1973; Nakayama and Yamamoto, 1977; Licciardello et al., 1977), and there was a sizeable difference in surface-to-volume ratio of the sticks and blocks used in this study.

The concentration of 0.15 percent sodium erythorbate applied in this investigation was an arbitrary selection based on reported usage levels of about 0.05 to 0.25 percent. In a future communication, the effect of concentration will be reported.

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U.S. 1981 Fish Catch Drops But Reaps Record $2.4 Billion

The U.S. fish catch in 1981 fell to 6 billion pounds, the lowest since 1977, but those fish brought a record dockside value of $2.4 billion, the Commerce Department's National Oceanic and Atmospheric Administration (NOAA) has announced. Although the volume of the 1981 catch was about 8 percent below that for 1980, a record year, NOAA's National Marine Fisheries Service said last year's catch was still 2 percent higher than the previous 5-year average.

The upward trend in the catch of edible fish and shellfish also appears to be continuing, according to the latest statistics. Estimated per capita consumption of fishery products edged up to 13.0 pounds in 1981 from 12.8 pounds in 1980.

The most valuable species caught in 1981 again was shrimp, worth more than $463 million at dockside. That was followed by salmon ($438 million), crabs ($297 million), and tunas ($206 million). The leading U.S. port in volume of commercial landings was Cameron, La., a distinction that city has held since 1978. It was followed by Los Angeles; Empire-Venice, La.; Pascagoula-Moss Point, Miss.; Dulac-Chauvin, La.; and Kodiak, Alaska.

Kodiak had the highest valued landings of any port in the nation, topping $132 million. Following were Los Angeles; New Bedford, Mass.; Dutch Harbor-Unalaska, Alaska; and Dulac-Chauvin. Louisiana led all states in volume with 1.2 billion pounds landed, mostly industrially important menhaden, followed by Alaska (975 million pounds), and California (775 million pounds). Alaska's catch, worth $640 million, was the country's highest. It was followed by California ($275 million) and Massachusetts ($197 million).

A Management Plan for New England Groundfish

A new plan to manage the cod, haddock, and yellowtail flounder fishery off the New England coast has been developed by the New England Fishery Management Council and approved by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service. It was implemented by emergency regulations effective 31 March 1982.

"The New England Council has worked with the industry for more than 2 years in developing this Interim Fishery Management Plan for Atlantic Groundfish," said William G. Gordon, NOAA's Assistant Administrator for Fisheries. "The result is a new approach to groundfish management." Gordon said the regulations for the plan include the basic management measures of minimum mesh size, minimum fish length, and voluntary catch reporting. The goal, according to Gordon, is to reduce the catching of small fish, enhance fish spawning, and collect accurate catch data. These goals are a major change from the present plan which uses quotas, trip limits, and mandatory reporting requirements to control catch. "We are able to relax the fishing regulations," Gordon said, "because of an increase in abundance of these fish stocks."

The plan will be effective for 3 years. During the first 2 years the Council has agreed to define its long-term management goals for these species and determine if certain levels of stocks should be maintained and what measures will be needed to reach those levels. Any additional protection measures will be implemented during the third year of the plan.

When asked when the fleet can actually begin to fish under the new plan, Gordon responded "On March 31, but this was not an easy date to arrive at. This new management approach requires NMFS to notify the public for its reaction to the plan and to process final regulations. The proposed regulations process could have kept the industry under the existing quotas until mid-summer. But after careful consideration of the record, the Secretary of Commerce has made the decision to implement the plan now, so that the industry can begin receiving its benefits."

The plan thus began on 31 March under emergency regulations for 90 days. During the first 45 days, the public was invited to comment on the proposed regulations. The Secretary also used the emergency period to monitor the fishery and see how well the plan was working. The final regulations were expected to be in force by mid-year.

The specific management measures included:

1) Optimum yield, which will be the

amount of fish actually harvested by the U.S. fishermen in accordance with the measures listed below.

2) Minimum mesh size for trawl net cod ends of 5⅛ inches the first year, and 5½ inches the following 2 years in a designated large mesh area. Gill nets must be 5½ inches. This large mesh area includes a part of the Gulf of Maine and Georges Bank areas, where about 90 percent of the cod, haddock, and yellowtail flounder are normally taken.

3) Minimum fish lengths of 17 inches for cod and haddock caught and kept or bought commercially, 15 inches for cod and haddock caught and kept by recreational fishermen, and 11 inches for yellowtail flounder. These minimum lengths apply to any cod, haddock, or yellowtail flounder, regardless of where caught.

4) An optional settlement program under which a vessel may fish in the large mesh area for species requiring the use of small mesh nets.

5) Spawning area closures (March, April, and May) are essentially the same as they were under the previous management system, though Area I has been modified slightly.

6) No change in permit requirements.

7) Collection of catch data is based upon a voluntary system being implemented by the Northeast Fisheries Center at Woods Hole, Mass. Fishermen with permits will be contacted concerning participation in the program.

For further information, contact Peter D. Colosi, Jr., National Marine Fisheries Service, State Fish Pier, Gloucester, MA 01930. Telephone (617) 281-3600, extension 272.

Sea Scallop Plan to Aid Reproduction and Harvest

The Fishery Management Plan for the Atlantic sea scallop fishery, approved by NMFS Assistant Administrator for Fisheries (NOAA) William G. Gordon on 26 April 1982, was implemented by emergency regulations on 15 May 1982. The plan was developed by the New England Fishery Management Council in consultation with the Mid-Atlantic and South Atlantic Councils, and has regulated the harvest of sea scallops, *Placopecten magellanicus,* throughout their range, from Maine through North Carolina.

The emergency regulations implemented a management program designed to protect and enhance the sea scallop fishery resource. The program is expected, over the long term, to increase the yield per scallop by about 10 percent, and the reproductive potential of the stock by about 35 percent, providing significant net economic benefits to fishermen, consumers, and the nation. These benefits will be achieved through a single conservation measure, a restriction on the size at harvest of sea scallops.

For the first year of implementation, sea scallops must meet a standard of 40 meat count (40 meats per pound), or a corresponding 3¼-inch (83 mm) shell height. Thereafter, the standard will rise to 30 meat count (30 meats per pound), or a corresponding 3½-inch (89 mm) shell height. The Regional Director of the National Marine Fisheries Service may then adjust the standard under limited circumstances within a range of from 40 to 25 meat count, in increments of 5 meat count, on a temporary basis.

Enforcement of the meat count standard will apply to sea scallops landed shucked and sold to a dealer up to the point in the U.S. where they are mixed, sorted, or processed. Sea scallops landed and sold in the shell must comply with the shell height standard up to the point in the U.S. where they are shucked. Sea scallops taken in Canada, under regulations which are substantially consistent with U.S. regulations, will be admitted to the United States if they are properly labeled and accompanied by a certificate of compliance issued by the Government of Canada.

All vessels harvesting sea scallops in quantities greater than 5 bushels or 25 pounds of meats per trip must obtain and carry on board a Federal fisheries permit with an endorsement for the sea scallop fishery. Information for management of the fishery will be collected as part of a voluntary fishery information collection program similar to that presently used by fishermen.

Fishermen had a 15-day grace period to restrict their harvests to scallops which met the meat count or shell height standards. A 60-day grace period was given so fishermen could apply for, and receive, their fishery permits.

New Albacore Fishing Area Holds Promise

Scientists with the Commerce Department's National Oceanic and Atmospheric Administration (NOAA), who completed preliminary evaluation of results of a 30-day albacore fishing expedition in waters 600-1,200 miles off San Diego earlier this year, are confident they have found a profitable winter fishing area for U.S. tuna fishermen. Izadore Barrett, director of NOAA's National Marine Fisheries Service Southwest Fisheries Center (SWFC) in La Jolla, Calif., said during January and February six chartered vessels conducted exploratory longline fishing for albacore tuna in waters not normally fished for the species.

The longline fishing method has not been used by U.S. tuna fishermen, according to Frank Mason of the American Fisherman's Research Foundation, an albacore fishing industry organization which cooperated in the project with NOAA. While on the fishing grounds the boats caught an average of about 0.5 ton per vessel, with high daily catches up to 1.5 tons. Albacore tuna sells for about $1,800 per ton dockside.

"By U.S. tuna industry standards, a fisherman could make some money out there," Barrett said, adding "not a huge amount, but enough to make the trip worth his time and effort." He pointed out that during the fall and winter months, most albacore vessels are used in crab, shrimp, and sablefish fishing. These fisheries have become increasingly competitive and, accord-

ingly, less profitable. The normal albacore season runs from July through October, and in the spring the vessels fish for salmon.

Barrett and Mason said albacore fishermen along the west coast have expressed considerable enthusiasm about the possibilities of productive winter fishing grounds. One ship was fishing out there early this year, Mason said, "and we expect a number will go out next winter."

The scientists were at a loss to explain why one of the six chartered vessels consistently caught more tuna than the other boats fishing in the same area. "We are going to look into every aspect of what he was doing, to try to find out what made the difference," Barrett said.

Albacore Tagged

During the expedition NOAA scientists tagged several albacore with ultrasonic transmitters, tracking one fish for 24 hours. The tracking results confirmed the belief that tuna cue on the ocean thermocline, that layer of water separating the warmer, oxygen-rich surface waters from the lower, colder ocean depths.

Vessels which cast their lines above the thermocline caught fewer than one fish per 100 hooks on the line, while those whose lines passed through the thermocline caught approximately eight fish per 100 hooks. This knowledge makes it economically feasible for the U.S. albacore tuna fleet, which until now has not fished during winter months, to expand its activities into the area being studied during months when the vessels normally would be idle, reports Michael Laurs of the SWFC.

In addition to measuring the potential catch, the six vessels are making observations on oceanographic conditions, collecting data for albacore biology and fishery studies, and tagging and releasing albacore for migration and stock structure studies.

The activity is sponsored by the American Fishermen's Research Foundation, a west coast industry group, under a grant from funds managed by NOAA's National Marine Fisheries Service.

Guam, Marianas Fishery Resources Are Surveyed

The NOAA ship *Townsend Cromwell* returned to Apra Harbor, Hawaii, on 16 April after a 15-day cruise around Guam and the Northern Mariana Islands where potential fishing grounds were surveyed and primary biological production and energy flow were assessed. The cruise was the first of a series of four to assess the fisheries resources, according to Richard S. Shomura, Director, Honolulu Laboratory, NMFS Southwest Fisheries Center.

Bert Kikkawa, Chief Scientist on the cruise reported that the bathymetry was conducted around Guam, Rota Island, Tinian, Saipan, and Farallon de Medinilla at bottom depths down to 600 fathoms (3,600 feet). One interesting result of this survey was the documentation that Farallon de Medinilla is surrounded by a very large bank with relatively large level plateaus at depths ranging from 50 fathoms (300 feet) to 400 fathoms (2,400 feet). These plateaus will be sampled for bottomfish and deepwater shrimps on subsequent cruises. Bathymetric data will be released after processing to aid local fishermen.

The biological assessment conducted during the cruise consisted of determining the abundance and distribution of the primary producers and zooplankton in their relationships to depth, light levels, and nutrient distribution.

Following the first bathymetric cruise, three biological cruises of 40 days each are scheduled. These will sample atulai (akule), tunas, bottomfishes, and shrimps along the Mariana Archipelago. The data collected on these cruises will be used to produce distributional charts and provide estimates of sustainable yields.

This series of research cruises is part of a cooperative agreement for the survey of the resources of the Mariana Archipelago that is being entered into by the Territory of Guam, the Commonwealth of the Northern Mariana Islands, and the United States (through the National Marine Fisheries Service and the U.S. Fish and Wildlife Service), according to Shomura. The *Townsend Cromwell* is commanded by Robert C. Roush.

Foreign Fishery Developments

Japan and Russia Sign Salmon Catch Quota Pact

Japan and the Soviet Union signed, on 23 April 1982, protocols on Japan's salmon catch quota for 1982 in the northwest Pacific Ocean. Japanese Charge d'Affaires Hisashi Owada and the Soviet Fisheries Minister Vladimir M. Kamentsev signed the protocols at the Fisheries Ministry in Moscow.

The agreement set the 1982 Japanese catch quota for salmon at the same amount, 42,500 metric tons, as in 1981. The fishing period, the restricted fishing zones, and fishery cooperation fee of ¥4 billion ($16 million) for 1982 remained also unchanged from 1981.

The two countries reached agreement on the salmon catch on 22 April in an unusually short period of 10 days. Both Owada and Kamentsev expressed satisfaction with the early conclusion of their negotiations. (Sources: LSB 82-6 and FFIR 82-8.)

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information Releases (FFIR) compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR) or Language Services Biweekly (LSB) reports produced by the Office of International Fisheries Affairs, National Marine Fisheries Service, NOAA, Washington, DC 20235.

The Expansion of the Mexican Tuna Fleet, 1981-1984

Table 1.—Mexico's tuna fleet, 1975-1984, by number and type of vessels and carrying capacity (cap.) in short tons.

Year[1]	Seiners No.	Seiners Cap.	Baitboats No.	Baitboats Cap.	Total No.	Total Cap.
1975	20	3,709	2	270	22	3,979
1976	25	13,860	2	270	27	14,130
1977	24	13,798			24	13,798
1978	23	13,437	2	174	25	13,611
1979	25	14,622	3	405	28	15,027
1980	46	35,162	6	705	52	35,867
1981	[2]45	[2]33,358	[2]10	[2]1,133	[2]55	[2]34,491
1982	[3]62	[3]53,458	[3]16	[3]2,033	[3]78	[3]55,491
1983	[3]91	[3]86,458	[3]22	[3]2,933	[3]113	[3]89,391
1984	[3]93	[3]87,958	[3]26	[3]3,533	[3]119	[3]91,491

[1]The number cited refers to the fleet at the end of the year.
[2]P = Preliminary
[3]E = Estimated based on current or planned construction.

Table 2.—Estimated cost and capacities (short tons) of tuna vessels under construction for Mexican owners as of January 1982.

Country	Type of vessel	No. of vessels	Carrying capacity	Cost[1] (10^6 US $)
Spain	Seiner	[2]21	[2]25,200	[2]225.0
Mexico	Seiner	14	13,200	[3]147.8
	Baitboat	16	2,400	[4]16.0
Italy	Seiner	7	8,400	64.5
U.S.	Seiner	4	5,200	32.8
Canada	Seiner	2	2,600	16.0
Norway	Seiner	2	2,400	23.2
Total		[4]66	[4]59,400	[4]525.3

[1]The February 1982 peso devaluation has substantially increased the peso cost of the vessels as the contracts with foreign shipyards were denominated in dollars.
[2]Estimated. Some reports indicate vessel cancellations; others suggest additional orders.
[3]The contracts with Mexican shipyards were denominated in pesos. The Division has used the old exchange rates to estimate the cost of the vessels. Unless the contracts are revised, however, the state-owned shipyards building the vessels will suffer significant losses as many of the engines and much of the equipment are imported and the peso cost of these items has doubled as a result of the February 1982 devaluation.
[4]Estimated.

Mexico is building one of the world's largest and most modern tuna fleets. The NMFS Division of Foreign Fisheries Analysis estimates that by the end of 1983, Mexico will have a fleet of 113 tuna vessels with a combined carrying capacity of nearly 90,000 tons[1]. Most of the newly built vessels will be purse seiners and will give Mexico the world's second largest fleet of tuna purse seiners.

Only the United States, with a 1981 fleet of 129 tuna purse seiners, has a larger fleet. Mexico's expansion of its tuna industry is an important part of its ambitious fisheries development program. Some Mexican observers, however, have now begun to question the fleet expansion program and believe that it may prove to have been a costly mistake.

Construction Plans

Mexico has launched the most ambitious fleet expansion program in the history of the eastern Pacific tuna fishery; it began to increase its tuna fleet significantly in 1980 when approximately 20 purse seiners were added (Table 1). An even larger increase is planned for 1982 and 1983. The Mexican Government and private companies have contracted for the construction of an estimated 66 tuna vessels in at least 16 different shipyards, both in Mexico and abroad (Table 2). The total cost of the vessels currently under construction exceeds an estimated $525 million[2], excluding financing (Table 2).

Shipyard Orders

The NMFS Division of Foreign Fisheries Analysis has obtained information on most of the orders placed by Mexico for tuna purse seiners and other vessels which could be used in the tuna fishery. The following shipyards were building vessels for Mexico as of January 1982. These summaries are based on a variety of press sources, often incomplete and sometimes contradictory. As a result, the actual figures may be slightly higher or lower, but they give an idea of the magnitude of Mexico's program to expand its tuna fleet.

Canada

Bel-Aire Shipyards Ltd.[3] of North Vancouver, B.C., is building two purse seiners for the Mexican firm Atunero Coinseco of Mexico City. Each vessel will be 69 m long with a carrying capacity of about 1,300 tons. The vessels will cost $8 million each; delivery is scheduled for December 1982.

Italy

The Societa Esercizio Cantieri (SEC) shipyard in Viareggio is building three tuna purse seiners for the Mexican firm Tuna del Pacifico. Each seiner will have a carrying capacity of 1,200 tons. The seiners will cost about $9.5 million each and are scheduled for delivery to private Mexican owners in 1982 and 1983.

Campanella Cantieri Navali shipyard in Savona is building four tuna purse seiners for four different Mexican companies (Pesquera del Noroeste, Atun del Noroeste, Pesquera Atuneros del Pacifico, and an unknown company). The vessels, similar to those being built by SEC, will

[1]Carrying capacities in this report are expressed in short tons (2,000 pounds).

[2]All values are reported in U.S. dollars unless otherwise specified.
[3]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

cost about $9 million each and will be delivered in 1982 and 1983.

Japan

Unspecified shipyards in Japan are building 10 longline vessels for Mexico's large state-owned fishing company Productos Pesqueros Mexicanos (PPM). These are the first longliners to be built for Mexico, and they will be the first such vessels to be deployed in Mexican waters by a wholly-owned Mexican company. The vessels are capable of tuna fishing but will reportedly be deployed in the shark fishery.

Mexico

Astilleros Rodriquez, S.A. (ARSA), a subsidiary of the Mexican Government's National Shipbuilding Company, Astilleros Mexicanos (Astimex), is building 16 baitboats (*Delfin* series) for PPM. The vessels will have carrying capacities of 150 tons each. Thirteen are being built at ARSA's Ensenada yard and three at the Santa Rosalia yard, both in Baja California. PPM will probably lease the vessels to cooperatives.

Construcciones Navales de Guaymas (Conagusa), located in Guaymas, is another Astimex subsidiary. It is building 16 tuna purse seiners (*Atun* series), each of which will have carrying capacities of 750 tons and will be 55 m long. Twelve are being built for PPM which obtained financing from Mexico's Banco Nacional Pesquero y Portuario (Banpesca), the state-owned fisheries development bank. Four of the twelve PPM seiners have already been delivered; the other eight will be delivered in 1982 (two), 1983 (four), and 1984 (two). The remaining four vessels were ordered by private Mexican companies (Pesquera Mar Atun and Pesquera San Martin) and an unknown company in Senegal. The seiners for the private Mexican companies have already been delivered at $5.2 million each.

Mexican Naval Shipyards in Salina Cruz (Yard Number 1) and Tampico (Yard Number 8) are building six tuna purse seiners for PPM. An American company based in San Pedro, Calif., Rados International Corporation, is providing technical assistance. Three seiners will be built at Salina Cruz, and the other three at Tampico. The vessels will be 71 m long and will have carrying capacities of 1,200 tons.

Norway

Heelesoy Skipsbyggeri has received an order for the construction of two tuna seiners for the Mexican company Pesquera Santa Ursula. Each vessel will be 69 m long and will have a carrying capacity of 1,200 tons. They are being built at a cost of $11.6 million each and the Norwegian Government is reportedly providing low interest financing. The two vessels are scheduled for delivery in December 1982 and April 1983.

Spain

Over half of Mexico's foreign orders for tuna seiners have been placed with Spanish shipyards. The Spanish Government is eager to assist their shipyards in obtaining foreign orders and the Banco Exterior de Espana has provided Mexico with some low interest credits to finance fishing vessel construction.

Maritima de Axpe in Bilbao is building seven tuna seiners[4] for Maratun, Tunamex, and Tunaoro. Each vessel will be 71 m long with a carrying capacity of 1,200 tons and will cost approximately $10.6 million each. They are scheduled for delivery in 1982 and 1983. The vessels for Maratun will be some of the best equipped seiners in the Mexican fleet as they are being equipped for satellite fishing.

Maritima de Musel in Gijon has been contracted by Mexican investors to construct four tuna purse seiners (*Aleta* series). Banpesca is financing the purchase for Compania Mexicana de Tunidos and Pesquerias del Pacifico (two seiners each). The seiners will be identical to those being built by Maritima de Axpe and will also be delivered in 1982 and 1983. The first of the four vessels, *Aleta Amarilla,* has already set sail for Mexico.

Mexican investors have also reportedly ordered 10 more tuna seiners from other Spanish shipyards. Information on these orders is contradictory and fragmentary. The vessels reportedly

[4]Unconfirmed reports suggest that the Axpe order may be modified. One report indicated that from one to three additional seiners may have been ordered. Another report claims that the original order has been cut back to only five seiners.

Norway-EEC Agree on Herring Quotas

Norway and the EEC have agreed to revised herring quotas for 1982. At the spring negotiations in Oslo, the EEC commission doubled the herring quotas which Norwegian fishermen can catch in the waters west of Scotland, bringing the total catch up to 12,000 metric tons (t) which is worth US$5 million. In addition, Norway was allocated a herring quota of 2,000 t which is to be fished south of the English Channel.

The information officer in the Ministry of Fisheries, Trond Wold, says that the EEC has in addition given its approval to a continuation of the brisling quota (60,000 t this year for Norway) until 12 January 1983.

In return, Norway has agreed to a quota of 3,000 t of cod, 3,000 t of haddock, 500 t of coalfish, and 350 t of shrimp in the North Sea, as well as 500 t of Norway haddock, to be fished in the Norwegian economic zone north of the 62nd parallel. The Norwegian allocation is also a compensation for the increased quota of blue whiting which Norway was granted by the EEC earlier this year. Norwegian fisheries authorities have expressed satisfaction over the agreement with the Common Market. (Source: Norwegian Information Service.)

cost about $11 million each. Delivery is scheduled for 1982 and 1983.

United States

U.S. shipyards are generally recognized to be the world's leader in the construction of tuna purse seiners. Many Mexican investors have a preference for U.S.-built vessels. U.S. shipbuilders, however, have had difficulty signing contracts with Mexican companies because of low interest financing made available by some foreign countries to attract orders for their domestic shipyards. U.S. shipyards have, nevertheless, won orders from some private Mexican investors.

The Bender Shipbuilding Company, Mobile, Ala., is building four 1,200 ton tuna purse seiners for various Mexican concerns. Two of the vessels, *Bruja del Mar* and *Bucanero,* have already been delivered to two Mexican companies, Atunera La Tris and Atun del Caribe respectively. The remaining two seiners currently under construction are for another company, Atuneros del Golfo y Pacifico, and should be delivered in 1983 at a cost of $8.4 million each.

Marco in Seattle, Wash., is building the last three 33 m purse seiners for Mexico, out of a nine vessel order. The purchase is being financed by Banpesca. Each vessel has a carrying capacity of 200 metric tons. The refrigeration units that are being installed can be used either for the tuna or the sardine fishery. It is likely that these vessels will be used in the sardine fishery as Mexico's current tuna fleet is already supplying more tuna than Mexico can utilize. All nine vessels are to be delivered to an unknown company in Mazatlan.

The Tacoma Boatyard, Tacoma, Wash., is building two 75 m tuna purse seiners for the Mexican Government. Each vessel will have a carrying capacity of 1,400 tons and cost $8 million. The delivery dates were May and June 1982, but the Mexican Government reportedly asked Tacoma Boatyard to delay delivery until late in 1982, as a result of a foreign exchange shortage caused by the February 1982 devaluation of the peso.

Types of Vessels

Most new tuna vessels ordered by Mexico are large tuna purse seiners. It is not known why the Mexicans chose to base the expansion of their tuna fleet primarily on these large seiners which are the most expensive type of vessel available for tuna fishing.

Large, modern purse seiners employ a relatively small number of fishermen and can operate at great distances from their ports. As a result, even though they may be costly to build, they are efficient fishing vessels for countries with high wage rates located at great distances from the fishing grounds. Mexico has, however, generally low wage rates, a severe unemployment problem, and several ports located near grounds which, in recent years, have been some of the most productive in the eastern tropical Pacific.

Tunas are highly migratory and in recent years, yellowfin and skipjack tuna schools in the eastern tropical Pacific have appeared off Mexico in significant quantities. This could change, however, because of the migratory nature of tuna and the great annual variations in its appearance. In previous years, tunas have appeared in larger quantities off Central and South America.

Many Mexican investors were reportedly impressed by the modern U.S. seiners which used to land tuna at Ensenada. This may have influenced the decision of some of the investors which ordered the seiners. Mexican officials may also have wanted vessels capable of fishing outside their claimed 200-mile Exclusive Economic Zone (EEZ). Some Mexican observers are now questioning the decision to concentrate on seiners, but as most of the seiners are already under construction it is too late to change the decision to build a major seiner fleet.

Mexico has not restricted its tuna fleet expansion program exclusively to purse seiners. Some longliners and baitboats are also being built. Mexico has ordered 10 longliners from Japan, but they will, reportedly, be deployed in the shark fishery. One longline vessel, however, is doing experimental tuna longlining in the Gulf of Mexico. Joint ventures along the Pacific coast have been formed with Japanese and Korean companies which make detailed reports to the Mexican Government on the quantity and composition of their catch. The catch of these joint ventures, however, is mainly billfish.

Mexico also plans to expand the baitboat fleet. Sixteen baitboats are be-

JAPANESE 1981 SURIMI PRODUCTION UP 6 PERCENT

Japanese frozen surimi (minced fish) production during January-December 1981 amounted to 306,657 metric tons (t), up 6.1 percent from the 1980 figure. Of this quantity, 192,264 t or 63 percent consisted of factoryship-processed production (motherships and large trawlers) and 114,393 t or 37 percent, land-based production. When compared with 1980, the 1981 production of factoryship-processed surimi increased 4.9 percent and production of land-based surimi increased 8.3 percent. The trend in the production of frozen surimi for 1972-1981 is shown below in Table 1. (Source: FFIR 82-6.)

Table 1.—Japanese frozen surimi production, 1972-81, metric tons.

Year	Factoryship	Land-based	Total	Year	Factoryship	Land-based	Total
1972	193,500	161,200	354,700	1977	168,823	191,769	360,592
1973	223,600	159,100	382,700	1978	183,012	132,433	315,445
1974	195,300	152,800	348,100	1979	180,401	114,425	294,827
1975	191,200	166,000	357,200	1980	183,232	105,668	288,900
1976	187,000	198,000	385,000	1981	192,264	114,393	306,657

ing constructed in Mexican shipyards for PPM. Some observers believe that these smaller, more labor-intensive baitboats could prove to be the most efficient vessels for the Mexican tuna industry, especially if they were owner operated. PPM reportedly plans, however, to lease the new baitboats to cooperatives. As a result, many observers, who have little confidence in the cooperatives, are skeptical about the baitboats.

Number of Vessels

Mexico's decision to build so many new tuna vessels is difficult to explain. Many Mexican observers, both Government officials and private investors, now consider it to be a serious mistake, and newspaper articles criticizing the Government's tuna policy have begun to appear.

The massive build-up of the Mexican fleet is the largest and the most rapid in the history of the eastern Pacific tuna fishery, despite Mexico's cutting back on its original plan. The Mexican Secretariat of Fisheries had initially planned on a tuna fleet of 150 large seiners. In an October 1981 meeting with tuna industry leaders, Mexican Fisheries Secretary Fernando Rafful announced that the tuna fleet, however, should not exceed 100-120 seiners. It now seems likely that the Mexican tuna fleet will be limited to the lower level of 100 seiners.

The number of vessels Mexico is adding to its fleet is clearly not justified by the quantity of tuna available in Mexico's 200-mile EEZ. The entire international seiner fleet only caught an average 87,800 tons of tuna per year in the Mexican EEZ during 1977-81 when tuna abundance off Mexico was at record high levels. This means that, theoretically, all of the tuna available in the Mexican EEZ could be caught in one trip by Mexico's new tuna fleet. Most Mexican tuna seiners, however, make three to four trips per year and thus the planned 1983 fleet will have the theoretical capacity of catching over 270,000 tons of tuna annually. (Based on the actual performance of Mexican tuna fishermen, however, the country's 1983 fleet could realistically be expected to catch about 150,000 tons of tuna, still substantially more than is available in the EEZ.) The tuna available in the Mexican EEZ could thus be fully utilized by a tuna fleet much smaller than the one Mexico is building.

To justify such a massive increase in its tuna fleet, the Mexican Government must have planned on fishing off other Latin American countries. A catch averaging 88,000 tons per year will not support a fleet profitably with a carrying capacity in excess of 90,000 tons. The huge number of new vessels Mexico is adding to its fleet is probably not even justified by the tuna available in the entire eastern Pacific Ocean.

Most biologists believe that the yellowfin tuna stocks, the most important tuna species in the eastern Pacific, are already overfished and that the impact of the greatly expanded fishing effort planned by Mexico is impossible to project. Yellowfin tuna yields have been declining for years, and many fishermen do not believe that they can continue fishing profitably for long if yields continue to decline. While yellowfin yields in the eastern Pacific as a whole have been declining, the decline has been much less severe in the northern area of the fishery off Mexico. It is likely that the increased Mexican effort will further impair yellowfin tuna catch rates, making the fishery even less attractive for U.S. and other foreign fishermen operating in the eastern Tropical Pacific.

Vessels

The total cost of the tuna vessels Mexico is currently building exceeds an estimated $0.5 billion, excluding financing (Table 1). The cost of financing and fully equipping these vessels could bring their total cost to almost $1 billion. Most of the vessel construction loans are for a 10-year period with interest rates running 7 to 11 percent. Banpesca charges an additional 1.8 percent charge for processing and guaranteeing the loans. Most of the new vessels are being financed through Banpesca, either with direct loans or with loan guarantees. This means that if the private owners cannot meet their payments, the Mexican Government is obligated to repay the loans. The only seiners being built without Banpesca

Norway's Fishing Fleet Growth Slowing Down

The Norwegian fishing fleet will receive only about 100 new vessels this year and this is much fewer than has been customary in recent years. The number of new vessels begun in the category 40-80 feet is expected to be halved from 20 to 10, and no new vessels of over 80 feet will be built, states Arnulf Midtgaard, director of the state fishermen's bank.

This is an unsatisfactory development for the over-40-feet category but there has been a strong renewal of the category 30-40 feet. Midtgaard said that the average age of large vessels has reached 20-30 years and this is too high. Although the interest for investment in the fishing fleet has declined, there is still such a large number of applications that they correspond to an amount three times as high as the loan frame within which the bank operates. The loan frame this year is US$38.6 million and of this US$8.3 million goes to new vessels, US$14 million to conversions, and US$6.6 million in connection with the sale and purchase of second-hand vessels.

The Ministry of Fisheries has instructed the bank to limit loans to vessels of 30-40 feet and reduce the number from 120 annually in the previous 2 years, to under 100 this year.

A vessel of 60-70 feet costs about US$833,000 and today it is impossible to pay the interest on this amount through investment in a fishing vessel. There are few who have private capital which can make it possible to acquire a vessel of this size, Midtgaard said. (Source: Norwegian Information Service.)

funds or loan guarantees are the ones under construction by Bender and the Tacoma Boatyard in the United States.

Economic Implications

The economics of the Mexican tuna industry have changed radically since 1979 and 1980 when many investors, some with no prior fishing experience, rushed into what they thought would be a lucrative new fishery. Many observers now believe that the Mexican tuna industry may require massive Government subsidies. Many private companies, already in the tuna industry, are now asking the Mexican Government for assistance. The new companies whose tuna seiners are still being built may require even greater financial aid following the devaluation of the Mexican peso.

The February 1982 decision by the Mexican Government allowing the peso to float has adversely affected the companies which ordered seiners in foreign shipyards. In just a few days, the Mexican peso fell from 23 pesos per US$1 to 45 pesos per US$1. The devaluation effectively doubled the peso value of the 36 seiners ordered abroad from 8.3 to 16.3 billion pesos, since all contracts with foreign shipyards were denominated in U.S. dollars. If Mexico were successfully exporting most of its tuna, the impact of the devaluation would be less severe because the dollar earnings could be used to repay the loans. But Mexico is marketing most of its tuna domestically. About 55,000 tons of Mexico's 76,000-ton 1981 tuna catch was marketed domestically. The earnings from such domestic sales are in the now devalued pesos. Mexican companies are faced with a serious dilemma. They will need to increase the domestic price of tuna to repay the dollar-denominated foreign loans. A substantial domestic price increase, however, would adversely affect sales and diminish the already inadequate domestic market.

The 1980 U.S. tuna embargo[5] has denied Mexican tuna companies access to the world's largest tuna market. Mexican companies have had difficulty finding alternative foreign markets. Much of the tuna that Mexico has been able to export has reportedly been sold at prices well below those prevailing in the United States. Tuna fishermen have been forced to rely on Mexico's small, domestic market for tuna. This has radically reduced their planned profits.

The prices available for tuna to Mexican tuna fishermen have declined sharply, and it is not yet clear at what level the Mexican Government will support those prices. Until the U.S. tuna embargo, Mexican fishermen could sell their catch to the United States where, in 1980, premium grade yellowfin tuna averaged $1,184 per ton, while the premium grade skipjack tuna averaged $1,082 per ton. Throughout most of 1981, massive purchases by state-owned Mexican canneries maintained domestic prices near U.S. levels, guaranteeing profitability to Mexican tuna fishermen. Mounting stocks of unsold canned tuna, however, have forced Mexican canneries, including the state-owned ones, to reduce or suspend tuna purchases in late 1981. As a result, tuna prices declined sharply, and some tuna was reportedly sold for as little as $600 to $700 per ton. The fishermen and the Government are now negotiating a contract which would ensure a guaranteed price. As of April 1982, however, the agreement had not yet been finalized. The Government is reportedly concerned about the potential cost of supporting the price near the U.S. levels as the fishermen are demanding.

Mexican tuna fishermen will be able to export some of their yellowfin tuna catch, mostly to European countries, at acceptable price levels, but export sales of skipjack will be much more difficult as European importers primarily want yellowfin tuna. Italy is Mexico's primary European customer, and almost all of the shipments to Italy have been yellowfin tuna.

Shipments to Europe will also yield profits below previous sales to the United States. The cost of shipping tuna to distant markets reduces the profits to Mexican companies. Before the U.S. tuna embargo, the tuna was simply landed in Ensenada and trucked across the border to nearby canneries in southern California.

Asian sales will be extremely difficult for Mexico. Countries such as the Philippines and Indonesia have begun to develop their skipjack tuna fisheries and, added to the already sizeable fisheries of Japan, Korea (ROK), and Taiwan, have sharply increased the quantity of skipjack tuna entering the international market. The increase has caused international skipjack prices to decline to as little as $800 per ton in early 1982.

Prices for skipjack tuna from the western Pacific (fish over 2.5 kg) at Japan's Shimizu market, for example, declined from $1,134 per ton in December 1981 to only $796 per ton in early March 1982. Unconfirmed reports, however, suggest that prices may have begun to increase somewhat in early April.

The Mexican Government faces some difficult economic choices. The country has not been able to market all of its 1981 tuna catch. Massive stocks of both frozen and canned tuna are reported in the ports of Ensenada and Mazatlan. By 1983, the tuna vessels ordered by Mexico will enable fishermen to increase significantly their tuna catch. Unless Mexico is able to find sizeable new export markets (which seems unlikely), the country will have to continue to rely on its domestic market. This will require the Mexican Government to budget substantial sums to subsidize domestic tuna sales. Failure to do so could mean the bankruptcy of many Mexican tuna companies, in which case the Government, through Banpesca, would be responsible for debts exceeding $1 billion. In addition to the tuna vessels currently under construction, Banpesca has previously financed the construction of an unknown number of tuna vessels as well as loans for the construction of cold stores and canneries for the tuna industry.

[5]The United States imposed the embargo on tuna and tuna products as a result of Mexico's seizure of the U.S. tuna vessels which were subsequently charged and fined for fishing for tuna in Mexico's 200-mile EEZ. The United States does not recognize coastal state jurisdiction over highly migratory species such as tuna.

Foreign Fisheries Market Reports Available from NTIS

The Division of Foreign Fisheries Analysis, National Marine Fisheries Service, NOAA, continuously receives reports on fisheries from the two U.S. Regional Fishery Attaches and various U.S. diplomatic posts. The Division sends the most interesting reports to the Department of Commerce for distribution through the National Technical Information Service (NTIS).

Some of these reports, as well as materials prepared independently by the Division and the NMFS Southeast Regional Office, are published as *Foreign Fishery Leaflets* or as international fishery reports. There are currently 191 reports available on 74 countries and regions. Fishery reports available as of 15 April 1982, are listed below and may be ordered from NTIS, U.S. Department of Commerce, Springfield, VA 22161.

Country/ Region	Title	Pages	Order no.	Price
World[1]	"Responses and Adjustments of Foreign Fleets to Controls Imposed by Coastal States, 1978"	49	DIB 79-03-034	$ 6.50
	"Atlantic Salmon"[2]	27	DIB 80-03-024	6.50
	"New Global Fishing Regime: Impact and Response"	7	PB 80-928004	6.50
Africa	"Possibilities of Expanding Exports of Fishery Products by Air 1977"	6	DIB 78-02-029	5.00
	"Government and Industry Fishery Organizations, 1979"	116	DIB 80-04-006	11.00
	"African Markets for Southeastern Fish Species, 1979"[4]	18	DIB 80-07-014	5.00
	"Recent Developments, 1980"	7	DIB 80-07-024	5.00
Argentina	"Argentine-Spanish Joint Fishing Ventures, 1979"[2]	11	DIB 80-04-007	5.00
	"Fishing Industry"	9	DIB 80-11-002	5.00
	"Fishing Industry Crisis, 1980"[3]	9	DIB 81-01-012	5.00
	"Fishing Industry, 1980"	52	ITA 81-11-036	8.00
Asia	"Handbook for Exporting Seafoods to the Orient, 1979"[5]	60	DIB 80-07-016	8.00
	"Buyer Contacts Made at USDA Red Meat, Poultry, and Fish Exhibit held in Japan, Korea (ROK), and Hong Kong"[5]	15	DIB 80-07-402	5.00
	"Gateway to Oriental Markets"[5]	74	DIB 80-10-011	8.00
Australia	"Market Research Concerning Fishing and Fish Processing Sector, 1978"	52	DIB 78-11-014	8.00
	"Fishing Industry, 1980"	16	ITA 81-08-006	5.00
Belgium	"Market for Fishery Products, 1978"	12	DIB 79-10-005	5.00
Belize	"Fisheries, 1980"[4]	14	ITA 81-08-008	5.00
Brazil	"The Fishing Industry in Brazil, 1976"	16	DIB 77-03-004	5.00
	"The Brazilian Lobster Industry, 1976"[3]	20	DIB 79-03-005	5.00
	"The Fishing Industry, 1977"	19	DIB 78-06-006	5.00
	"The Fishing Industry, 1978"	16	DIB 79-03-004	5.00
	"The Fishing Industry, 1979"	12	DIB 80-03-013	5.00
	"The Fishing Industry, 1980"	37	DIB 81-03-090	6.50
	"The Fishing Industry, 1980"	25	ITA 81-08-041	5.00
	"The Fishing Industry, 1981"	37	ITA 82-03-012	5.00
Burundi	"Fishing Industry, 1975"[2]	3	DIB 77-02-025	5.00
Cameroon	"Fisheries of Cameroon and Equatorial Guinea, 1980"	9	ITA 81-11-047	5.00
Canada	"Fishery Resources in the Atlantic Region, 1978"	10	DIB 78-10-028	5.00
	"Canadian Subsidies to the Fishing Industry, 1978"	9	DIB 79-03-026	5.00
	"Fisheries in British Columbia, 1978"	8	DIB 79-10-003	5.00
Canary Islands	"Fishing Port at Santa Cruz de Tenerife, 1975"[4]	10	DIB 77-12-040	5.00
Caribbean	"7th Annual Carib-USA Food Exhibit"	10	ITA 81-11-038	5.00
Chile	"Fishing Industry, 1979"	31	DIB 80-03-030	6.50
Colombia	"Market Assessment, 1980"	7	ITA 81-11-037	$ 5.00
Denmark	"Fisheries, 1974"[3,4]	12	DIB 78-01-038	5.00
	"Fisheries, 1975"[3,4]	7	DIB 77-08-042	5.00
	"Fisheries, 1976"[4]	22	DIB 77-10-027	5.00
Djibouti	"Small Scale Fisheries Development, 1978"	97	DIB 79-10-500	10.00
Ecuador	"Fisheries, 1975"	14	DIB 76-11-014	5.00
	"Fisheries, 1977"	49	DIB 77-12-038	6.50
	"Fisheries, 1978"	40	DIB 79-03-006	6.50
	"Fisheries, 1979"	11	DIB 80-03-010	5.00
	"Market Study: Commercial Fishing Equipment, 1980"	29	DIB 80-10-002	6.50
	"Fisheries, 1979-80"	17	DIB 81-01-015	5.00
	"Shrimp Fishery 1980-81"[2]	16	ITA 81-11-046	5.00
	"Fisheries, 1981"	41	ITA 82-03-033	5.00
	"Shrimp Fishery, 1980-81"	16	ITA 81-11-046	5.00
	"Fisheries, 1981"	41	ITA 82-03-033	5.00
Egypt	"Fisheries Status Report, 1976"[2]	10	DIB 77-11-033	5.00
	"Fisheries, 1977"	50	DIB 78-07-029	6.50
El Salvador	"Market for Processed Fish and Shellfish, 1977"	26	DIB 78-01-034	6.50
Equatorial Guinea	"Fisheries of Equatorial Guinea and Cameroon, 1980"	9	ITA 81-11-047	5.00
Ethiopia	"Fisheries, 1978"	3	DIB 79-10-009	5.00
Gabon	"Fishing Industry, 1979"	4	DIB 80-03-012	5.00
Gambia	"Fisheries, 1977"[3,4]	8	DIB 78-07-027	5.00
Germany (FRG)	"German Squid Market, 1976"	5	DIB 77-03-032	5.00
	"Fishery Policy and Catches, 1977-78"	6	DIB 78-12-031	5.00
	"Food Buyer Contacts Made at ANUGA, World Food Market, 1979"[5]	50	DIB 80-07-400	7.00
Ghana	"Fisheries, 1976"[3]	28	DIB 78-06-008	6.50
Greece	"Potential for Increasing Exports of U.S. Fishery Products to Greece, 1981"[5]	25	ITA 82-03-003	5.00
Guyana	"Fisheries, 1980"[2]	6	DIB 80-07-022	5.00
Haiti	"Fish Imports and Consumption, 1975"	3	DIB 77-08-005	5.00
Honduras	"Fisheries, 1980"[4]	10	ITA 81-11-040	5.00
Hong Kong	"Fisheries, 1978"[4]	25	DIB 79-10-008	5.00
	"Gateway to Oriental Markets"[5]	74	DIB 80-10-011	5.00
Iceland	"Fishing Industry, 1976"[4]	8	DIB 77-08-009	5.00
	"Fishing Industry, 1977"	4	DIB 78-12-032	5.00
India	"Indian Fisheries: Problems and Prospects, 1977"	16	DIB 78-03-019	5.00
	"Market Research: Ships, Ports, Fish, Fish Processing, and Oceanographic Equipment, 1979"	127	DIB 80-03-502	10.00
	"Fisheries: Problems and Prospects, 1980"	10	ITA 81-11-034	5.00
Indonesia	"Fishing Industry Report, 1979"	25	DIB 80-05-004	5.00
Ireland	"Fishery Developments, 1978"	13	DIB 79-10-004	5.00
Ivory Coast	"Prospects for Fisheries, 1976"	7	DIB 77-11-031	5.00
Japan	"Direction of Technological Development" (Hatcheries and			

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	Stock Preservation)	21	DIB 76-06-012	$ 5.00
	"Fisheries, 1975"[3]	59	DIB 78-01-039	8.00
	"Marketing Consumer Products in Japan, 1976"	18	DIB 76-06-025	5.00
	"Market Survey for Oceanographic, Offshore, Marine, Shipboard, Port, and Dockside Equipment in Japan, 1977"	124	DIB 78-02-505	10.00
	"Ocean Development, 1977"	33	DIB 78-04-038	6.50
	"Market for U.S. Fishery Products, 1978"	4	DIB 79-04-004	5.00
	"Market for Blackfin Tuna, 1980"[5]	10	DIB 80-07-021	5.00
	"Gateway to Oriental Markets"[5]	74	DIB 80-10-011	8.00
Kenya	"Fisheries, 1975"[4]	23	DIB 78-06-009	5.00
Korea (ROK)	"Market Brief: Fishing Equipment, 1978"	9	DIB 78-11-012	5.00
	"Recent Trends in Fisheries, 1978"	10	DIB 79-03-007	5.00
	"Harbor, Dockside, and Marine Equipment, 1979"	31	DIB 80-05-504	10.00
	"Gateway to Oriental Markets"[5]	74	DIB 80-10-011	8.00
Kuwait	"Special Fisheries Report, 1980"[5]	21	DIB 80-07-018	5.00
Latin America	"Government and Industry Organization, 1971"	176	DIB 78-11-015	15.50
	"Fishery Developments, 1979-80"	26	DIB 80-09-004	6.50
	"Foreign Fishery Policies"	8	ITA 81-11-042	5.00
Liberia	"Fisheries, 1976"[4]	21	DIB 77-12-041	5.00
Madagascar	"Fisheries, 1974"[3,4]	25	DIB 77-08-043	5.00
Malaysia	"Fisheries, 1976-77"[4]	14	DIB 78-08-031	5.00
Mauritania	"Fishing Companies, 1974"[4]	20	PB 261-862	5.00
	"Fisheries, 1974"[3,4]	37	DIB 77-08-044	6.50
	"International Fishery Relations"[3,4]	9	DIB 77-08-039	5.00
Mexico	"Fisheries Development Plan, 1977"[2]	4	DIB 77-11-034	5.00
	"Latest Developments in Fisheries, 1977"[2]	9	DIB 77-11-036	5.00
	"Fishing Industry Equipment, 1979"	12	DIB 79-10-002	5.00
	"Fisheries Policy and the Underdevelopment of Inshore Pacific Mexico, 1979"	45	PB297-160/AS	6.50
	"Fishery Development, 1979"[2]	46	DIB 80-07-017	6.50
	"Market Survey for Commercial Fishing Equipment, 1980"	162	DIB 80-08-506	10.00
	"Fishing Industry, 1979-80"[4]	7	DIB 80-10-009	5.00
	"Fisheries, 1980"	9	ITA 81-11-041	5.00
	"Fishery Importers, 1981"	10	ITA 81-11-045	5.00
	"The Fishing Industry, 1980"[4]	26	PB 81-207003	6.50
	"Fishery Cooperatives"	80	ITA 82-01-013	5.00
	"The Fishing Industry, 1981"[4]	13	ITA 82-03-034	5.00
Middle East	"Government and Industry Fishery Organizations, 1977"	176	DIB 78-11-015	15.50
Morocco	"Fisheries, 1975"[4]	144	DIB 77-08-010	12.50
	"International Fishery Relations, 1977"[4]	6	DIB 77-11-030	5.00
	"Fisheries, 1979"	8	DIB 80-08-009	5.00
Netherlands	"Food Buyers Contacts made at ROKA, Holland's Biennial Food Show, 1980"[5]	25	DIB 80-07-401	5.00
	"Fisheries in the Netherlands, 1979"	18	DIB 80-09-003	5.00
Netherland Antilles	"Fisheries, 1980-81"	8	ITA 82-05-015	5.00
New Zealand	"Lobster Fishery, 1975"	7	DIB 77-08-045	5.00
	"Commercial Fishing Equipment: Possibilities for Sales"	1	DIB 77-08-017	5.00
Nicaragua	"Fish and Fish Products, 1977"	14	DIB 78-02-028	5.00
	"Fisheries, 1980"[4]	9	ITA 81-11-044	5.00
Nigeria	"Marketing Survey: Fish, 1980"	10	DIB 78-10-027	5.00
	"Annual Fisheries Report, 1980"	24	ITA 81-11-033	5.00
	"Annual Fisheries Report, 1981"	24	ITA 82-01-014	5.00
Norway	"Annual Outlook: Fishing Industry, 1976"	11	DIB 77-09-021	5.00

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	"Fishing Industry, 1979"	8	DIB 81-01-014	$ 5.00
	"Fishing Industry, 1980"	7	DIB 81-03-061	5.00
Panama	"Fishing Industry, 1973"[3]	23	PB 246-597	5.00
	"Fishing Industry, 1975"	26	DIB 76-09-027	6.50
	"Fishing Industry, 1976"	54	DIB 77-10-019	8.00
	"Fishing Industry, 1977"	7	DIB 78-09-017	5.00
	"Fishing Industry, 1978"	16	DIB 80-03-011	5.00
	"Fishing Industry, 1979-80"	28	DIB 81-01-008	6.50
	"Fishing Equipment and Supplies, 1980"	45	ITA 81-10-043	6.50
	"Fishing Industry, 1981"	25	ITA 82-01-012	5.00
Peru	"Fisheries Expansion, 1978"[2]	7	DIB 80-03-021	5.00
	"Reduction Fishing Restrictions, 1979"[2]	8	DIB 80-03-022	5.00
	"Fishery Developments, 1980"[2]	5	DIB 80-07-023	5.00
	"Fishing Industry, 1980"[2]	6	DIB 81-01-013	5.00
	"Fishing Industry, 1979-80"[2]	5	DIB 80-10-007	5.00
Philippines	"Fishing Industry Developments, 1976"[2]	5	DIB 77-03-002	5.00
	"Fisheries, 1978"[4]	24	DIB 79-10-006	5.00
	"Fisheries, 1979"	19	DIB 80-10-010	5.00
	"Fishing Industry, 1979-80"	6	DIB 80-12-012	5.00
Poland	"Current State of Polish Fishing Industry, 1980"	5	ITA 81-11-032	5.00
Portugal	"Fishing Industry, 1980"	10	DIB 81-03-056	5.00
Saudi Arabia	"Fishing Industry, 1978"	8	DIB 79-04-011	5.00
Senegal	"Lobster Fishery, 1976"[2]	6	DIB 77-11-037	5.00
	"Fisheries, 1975-76"[3]	10	DIB 78-10-029	5.00
	"Industry Market Study, 1980"	27	ITA 81-08-005	5.00
Sierra Leone	"Fisheries, 1976"[4]	32	DIB 77-08-008	6.50
Singapore	"Fisheries, 1976-77"[4]	8	DIB 78-08-030	5.00
S. Africa	"Fishing Industry, 1975-76"	15	DIB 77-08-041	5.00
	"Lobster Fisheries in South Africa and Namibia, 1975-76"	24	DIB 78-02-027	5.00
	"Fisheries, 1977"	7	DIB 78-04-035	5.00
	"Fisheries, 1979"	5	DIB 80-11-001	5.00
	"Fisheries, 1980"	10	ITA 81-11-035	5.00
	"Fisheries, 1981"	10	ITA 82-03-011	5.00
S. Pacific	"Eighth South Pacific Forum Documents, 1977"	13	DIB 77-11-038	5.00
Sweden	"Fishing Industry, 1975"	3	DIB 76-02-002	5.00
	"Fishing Industry, 1976"	7	DIB 76-09-017	5.00
	"Fish and Fish Products, 1974-76"	7	DIB 77-05-015	5.00
	"Shrimp Fishery, 1977"	8	DIB 78-11-011	5.00
	"Fishing Industry, 1978"	15	DIB 79-10-015	5.00
	"Fishing Industry, 1980"	17	PB 81-226-318	5.00
Taiwan	"Fishing Industry, 1975"	8	DIB 77-02-031	5.00
	"Fishing Production, 1976"	11	DIB 77-09-026	5.00
	"Fishing Industry, 1977"	5	DIB 78-03-012	5.00
	"Catch for Jan.-Oct. 1977 and Recent Fishery Developments"	13	DIB 78-04-036	5.00
	"Indebtedness and General Financial Situation, 1977"	3	DIB 78-09-022	5.00
	"Fishery Catches, January-June 1978"	10	DIB 78-12-010	5.00
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	"U.S. Food Show, 1980"	15	ITA 81-11-039	5.00
	"The Fishing Industry, 1981"	19	ITA 82-03-013	5.00

[1]See also regional listings for Africa, Asia, the Caribbean, Latin America, and the Middle East.
[2]Previously released as an "International Fishery Report" by the NMFS Division of Foreign Fisheries Analysis.
[3]Previously released as a *Foreign Fishery Leaflet*.
[4]Prepared by the Regional Fishery Attache.
[5]Prepared by the Commercial Development Services Branch, NMFS Southeast Regional Office.

Resource Management and Public Information

Natural resource management has long been viewed as 10 percent resource management and 90 percent public management. "**Public Relations and Communications for Natural Resource Managers,**" by James R. Fazio and the late Douglas L. Gilbert, should then be the "bible" for natural resource managers. In fact, it is too rarely consulted, even though more and more natural resource decisions are made contingent on public feelings and input.

Obviously the time to employ this book is before a problem begins, for it is a thorough guide to how an effective natural resource public communications program can and should be run. Indeed, it provides sound advice on how resource professionals can give the public the best information available so that good decisions can be made. The authors point out that honesty in natural resource communications is the best policy.

The authors review public relations problems in natural resource agencies and the history of resource management. They provide seven basic and time-tested principles of public relations, tell how to identify and work with the various publics, the many user and interest groups. The tools of public relations are well covered as are each of the vital communication techniques: Personal contacts, the print media, electronic media, and exhibits, special events, and photography.

Sound planning is also detailed—issue analysis, goals and objectives, communications channels, timing, evaluation, public involvement, etc. A chapter is also devoted to government structure and the legislative process and to special emergency information services, as well as a look at the future of people and natural resource management.

Each chapter provides suggested additional references and the book contains a bibliography of cited references. Indexed, the 375-page hardbound volume is available from the publisher, Kendall/Hunt Publishing Company, 2460 Kerper Blvd., Dubuque, Iowa 52001 for $19.95.

Techniques of Warmwater Fish Culture: Israel's Methods and Results

"**Commercial Fish Farming,**" subtitled "With Special Reference to Fish Culture in Israel," has been published by John Wiley & Sons, Inc., One Wiley Drive, Somerset, NJ 08873. Authors are Balfour Hepher and Yoel Pruginin, respectively senior research scientist at the Fish and Aquaculture Station, Dor, Israel, and chief extension officer on aquaculture in the Israeli Ministry of Agriculture.

Fish culture techniques developed and refined over the last 40 years in Israel have raised average fish production there from 1.5 tons/hectare to almost 4.0 tons/hectare. The best fish farms produce over 7 tons/hectare. This volume thoroughly and clearly describes the principles and practices that sustain such warmwater production and which are, of course, applicable in many other parts of the world.

After a brief introduction on fish farm development in Israel, the authors describe site selection (soil and topography) and such necessities as the quantity, quality, and temperature of water, along with planning the farm unit and its layout and water supply. Pond construction basics (size, shape, depth, etc.) are also detailed.

Species cultured (common carp, Chinese carp, tilapia, and gray mullet) are reviewed, along with the biological and economic considerations in culture methods. Proper planning and recordkeeping are stressed. Techniques and equipment are discussed for routine work through feeding, sampling, harvesting, weed control, etc. A chapter is devoted to chemical fertilization, manuring, culturing ducks with fish, and use of wastewater in fish ponds. Other chapters are devoted to nutrition and feeding, hazards and diseases, and fish farming economics.

Fish reproduction techniques, selection of broodstock, induced spawning, collecting fry from natural habitats, and hatchery breeding, are reviewed. Both polyculture and monoculture are discussed.

Thorough and well-illustrated, the volume will likely be useful to not only managers of fish farms, but to biologists, students, and professors of aquaculture. Indexed, and with extensive references, the 261-page hardbound volume is available from the publisher for $32.50 plus $0.86 postage.

Induced Fish Breeding: A Workshop Report

Publication of "**Induced Fish Breeding in Southeast Asia**" has been announced by the International Development Research Center. Edited by F. Brian Davy and Amy Chouinard, it is the report of a workshop held in Singapore on 25-28 November 1980, where participants gave state-of-the-art reports from a variety of countries. This small volume summarizes those presentations, reviewing gonadal maturation, induced spawning, storage of fish gametes, and larval rearing and makes recommendations for further progress in each area. Appendices list finfish production in south and southeast Asia, and institutions involved in induced fish breeding research. A bibliography is provided.

The small (6½ × 9¾″) 48-page paperbound volume is available in the United States from UNIPUB, 345 Park Avenue South, New York, NY 10010 for $4.50; elsewhere it is available from the IDRC Communications Division, P.O. Box 8500, Ottawa, Canada K1G 3H9.

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

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Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

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Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10-inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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